2007 Chemical Biological Information Systems (CBIS) Conference and Exhibition
8-11 January 2007

Austin, Texas

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Hazard and Environment Modeling – Trinity Room A&B (11:00 – Noon):

- *"Estimating Emissions of Toxic Industrial Chemicals (TICs) Released as a Result of Accidents or Sabotage"*, Dr. Steven R. Hanna, Hanna Consultants

Data Assimilation and Tactical Applications – Pecos Room (11:00 – Noon) :

- *" Sensor Networks for Indoor Sensor Data Fusion"*, Ms. Priya Sreedharan, Lawrence Berkeley National Laboratory (LBNL)

Data and Decision Support Tools – San Marcos Room (11:00 – Noon):

- *"A Web-Based Knowledge Exploitation Toolset for the CBDP"*, Mr. Gaylen Drape, ENSCO, Inc

Medical Modeling – San Antonio Room (11:00 – Noon):

  - *"Shape Signatures: Next-Generation Drug Discovery Tool"*, Dr. William J. Welsh, University of Medicine & Dentistry of New Jersey Robert Wood Johnson Medical School
  - "Medical Modeling of Particle Size Effects for Inhalation Hazards", Dr. Gene E. McClellan, Applied Research Associates, Inc.

BREAKOUT SESSION

Hazard and Environmental Modeling – Trinity Room A&B (1:00 – 2:30 PM):

- *"Fast Pressure Calculations on Buildings to Improve Outdoor-to-Indoor Transport & Dispersion"*, Dr. Michael J. Brown, Los Alamos National Laboratory (LANL)

Major Defense Acquisition Programs – Pecos Room (1:00 – 2:30 PM):

- *"Chemical And Biological Defense Modeling and Simulation S&T Support to MDAP Thrust (CBD M&S S&T Support to MDAP"*, Mr. William Zimmerman, Naval Surface Warfare Center (NSWC) Dahlgren
- *"Use of a Synthetic Environment to Support Acquisition"*, Ms. Deb Fish, Defence Science and Technology Laboratory, UK
- *"Chem-Bio System Military Worth Assessment Toolkit"*, Mr. Chris J. Gaughan, Edgewood Chemical Biological Center

Decision Support Tools – San Marcos Room (1:00 – 2:00 PM):

- *"Next Generation Tactical Situation Assessment Technology (TSAT)"*, Dr. Lorraine Duffy, Ph.D, JPM IS
- *"Multi-Purpose Machine-Intelligent-based Information Fusion (FLASH)"*, Dr. Jerome J. Braun, Massachusetts Institute of Technology (MIT) Lincoln Laboratory

Medical Systems – San Antonio Room (1:00 – 2:30 PM):

- *"A Bayesian Approach for Estimating Outbreak Characteristics from Patient Data"*, Dr. Jaideep Ray, Sandia National Laboratories
- *"Effectiveness of Urban Shelter-In-Place (SIP): What factors affect effectiveness"*, Dr. Ashok Gadgil, Lawrence Berkeley National Laboratory

Hazard and Environmental Modeling – Trinity Room A&B (3:30 – 5:30 PM):

- *"MicroSWIFT/SPRAY (MSS)"*, Dr. Thomas B. Harris, Science Applications International Corporation (SAIC)
- *"A Fast-Running, High Quality, Transport and Dispersion System for Urban Areas"*, Dr. Donald A. Burrows, ITT Industries
- *"Urban Dispersion and Data Handling in JEM"*, Mr. Ian Griffiths, Defence Science and Technology Laboratory (DSTL)

Major Defense Acquisition Programs – Pecos Room (3:30 – 5:30 PM):

- *"A Comprehensive Methodology for Evaluating the Effectiveness of CBRN Protection Systems"*, Mr. Steven S. Streetman, ENSCO, Inc

Battle Management – Sabine Room (3:30 – 5:30 PM):

- *" Programmable Software Defined Radio"*, Mr. Chris Wasser, Northrop Grumman

Data and Decision Support Tools – San Marcos Room (3:30 – 5:30 PM):

- *"Decision Support Using Mission Simulation and Modeling Tools"*, Dr. Gerald R. Larocque, Ph.D, Massachusetts Institute of Technology (MIT) Lincoln Laboratory
  - "Multi-Objective Optimization Methods for Optimal Funding Allocations to Mitigate Chemical and Biological Attacks", Mr. Roshan Rammohan, University of New Mexico
  - *"A Proposed Open Standard Architecture for Modeling and Simulation (OSAMS)"*, Mr. Jeffrey S. Steinman, Ph.D, WarpIV Technologies, Inc
  - *"BROOM: An Integrated Data Management and Analysis System for Chemical and Biological Restoration"*, Mr. James L. Ramsey, Sandia National Laboratories

11 January 2007

BREAKOUT SESSION

Hazard and Environmental Modeling – Trinity Room A&B (8:45 – 10:15 AM)

- *"Evaluations of URBAN HPAC Configurations with Joint Urban 2003 Field Trials"*, Dr. Nathan Platt, Institute for Defense Analyses
- *"Joint Effects Model Urban IPT"*, Dr. James Heagy, Institute for Defense Analyses

Data Assimilation and Tactical Applications – Pecos Room (8:45 – 10:15 AM):

- *"Sensor Placement Algorithm for Rapid Theatre Assessment (SPARTA)"*, Dr. Martyn D. Bull and Dr. Robert Gordon, RiskaWare
- *"Optimal Networks for Siting Bio-Samplers in Buildings"*, Dr. Michael D. Sohn, Lawrence Berkeley National Laboratory (LBNL)
- *"Sensor Location Optimization Tool Set (SLOTS)"*, Mr. Michael J. Smith, ITT

Data and Decision Support Tools – San Marcos Room (8:45 – 10:15 AM):

- *"A Modular Architecture for Multivariate Investment Decision Support"*, Ms. Shan Xia, University of New Mexico

Threat Agent Science – San Antonio Room (8:45 – 10:15 AM):

- *"Computational Chemistry: Example Applications of a Critically Important Tool in Threat Agent Science"*, Dr. Douglas Burns, ENSCO, Inc

Hazard and Environmental Modeling – Trinity Room A&B (11:00 – Noon):

- *"National Centers for Environmental Prediction (NCEP) Meteorological Model Predictions for Dispersion Applications"*, Mr. Jeffery T. McQueen, NOAA/NWS/NCEP/EMC

Data and Decision Support Tools – San Marcos Room (11:00 – Noon):

- *"Decision Aids for CBRN Investment Planning & Analysis"* , Dr. Heidi Ammerlahn, Sandia National Laboratories
- *"Chem-Bio Virtual Prototyping Benefit and Feasibility"*, Mr. Michael O. Kierzewski, US Army RDECOM, ECBC
- *"Atmospheric Chemistry of Toxic Industrial Chemicals"*, Mr. Michael Henley, Air Force Research Lab/MLQL
- *"Improvement and Sensitivity Analysis of the Atmospheric Chemistry Module for Modeling TICs in SCIPUFF"*, Dr Douglas Burns, ENSCO, Inc

Hazard and Environmental Modeling – Trinity Room A&B (1:00 – 2:30 PM):

- *"Supporting Transport and Dispersion Modeling with Stochastic Weather"*, Major (PhD) Tony Eckel, Air Force Weather Agency (AFWA)
- *"Joint Effects Model (JEM) Environmental Services Research and Development"*, Mr. George Biberbach, National Center for Atmospheric Research
- *"Turbulence in the Stable Boundary Layer"*, Dr. Dennis M. Garvey, Army Research Laboratory

Operational Effects – Sabine Room (1:00 – 2:30 PM):

- *"Development of CBRN Impact Assessment Capabilities"*, Mr. Christopher M. Clem, Defence Science and Technology Laboratory (DSTL)
- *"Impact Framework"*, Mr. Andrew Howe, Defence Science and Technology Laboratory (DSTL)
- *"Using Experimentation to Support Future Capability Needs: Chem-Bio Effects in the JFCOM Urban Resolve Experiment"*, Mr. Ian Griffiths, Defence Science and Technology Laboratory (DSTL)

Testing & Evaluation – San Marcos Room (1:00 – 2:30 PM):

- *"A New M&S Tool to Supplant Decontamination Testing: The Decontamination Efficacy Prediction Model"*, Dr. Leonard N. Carter, U.S. Army Dugway Proving Ground

Threat Agent Science – San Antonio Room (1:00 – 2:30 PM):

- *"Scalable Transport Models for Non-Evaporating and Evaporating Sessile Droplets within Porous Substrates"*, Mr. Homayun K. Navaz, Kettering University
- *"Agent Fate Predictive Modeling"*, Mr. William (Bill) Kilpatrick, Air Force Research Laboratory (AFRL)

Hazard and Environmental Modeling – Trinity Room A&B (3:00 – 5:30 PM):

- *"Assessing the Impact of Meteorological Model Uncertainty on SCIPUFF Atmospheric Transport and Dispersion Predications"*, Dr. Leonard J. Peltier, Applied Research Laboratory, Pennsylvania State University
- *"A Practical Method for Calibration of Ensemble Spread for Representation of Meteorological Uncertainty in Atmospheric Transport and Dispersion Models"*, Mr. Walter Kolczynski, Jr., Pennsylvania State University
- *"Progress Towards an Improved High-Fidelity Forecasting Capability using Combined Mesoscale and Microscale Models"*, Dr. William J. Coirier, CFDRC
- *'Development of an HPAC/JEM Waterborne Chemical and Biological Agent Transport Modeling Capability"*, Mr. Matthew C. Ward, Applied Sciences Associates.

Operational Effects – Sabine Room (3:00 – 5:30 PM):

- *"CBRN Data Import Export Tool"*, Mr. Darius Munshi, Cubic Defense Applications

- *"Side-By-Side Comparison of Mobile Force Modeling Methods for Operational Effects and Virtual Prototyping",* Mr. Camillus W.D. "Dave" Hoffman, PI, University of New Mexico

Testing and Evaluation – San Marcos Room (3:00 – 5:30 PM):

- *"Concentration Fluctuation Model for the Virtual Testing of CBRN Detector Systems"*, Dr. Martyn Bull, Riskware, Ltd.
- *"HAPPIE: The Dutch Missile Intercept Consequence Simulator"*, Dr. Elena Abadijieva , TNO Defence, Security and Safety
- *"Standardizing VV&A Documentation"*, Ms. Jennifer Park, JPEO CBD SSA

Threat Agent Science – San Antonio Room (3:00 – 5:30 PM):

- *"Quantum-Chemical Theory Modeling of Chemical Warfare Agent/Adsorbent Interaction"*, Lt. Jennifer Plourde, Air Force Research Lab, Dr. Tom J. Evans, PhD, Cubic Defense Applications
  - *"Next-Generation Computational Chemistry Tools to Predict Toxicity of CWAs"*, Dr. William (Bill) J. Welsh, University of Medicine & Dentistry of New Jersey Robert Wood Johnson Medical School

Chemical and Biological Information Systems (CBIS) Conference & Exhibition

January 8 – 12 2007
Austin Texas

HAPPIE

THE DUTCH BALLISTIC MISSILE INTERCEPT CONSEQUENCE SIMULATOR

Dr. Elena Abadjieva, Reinier Sterkenburg, François Bouquet, Peter Doup

TNO Defence, Security and Safety The Netherlands

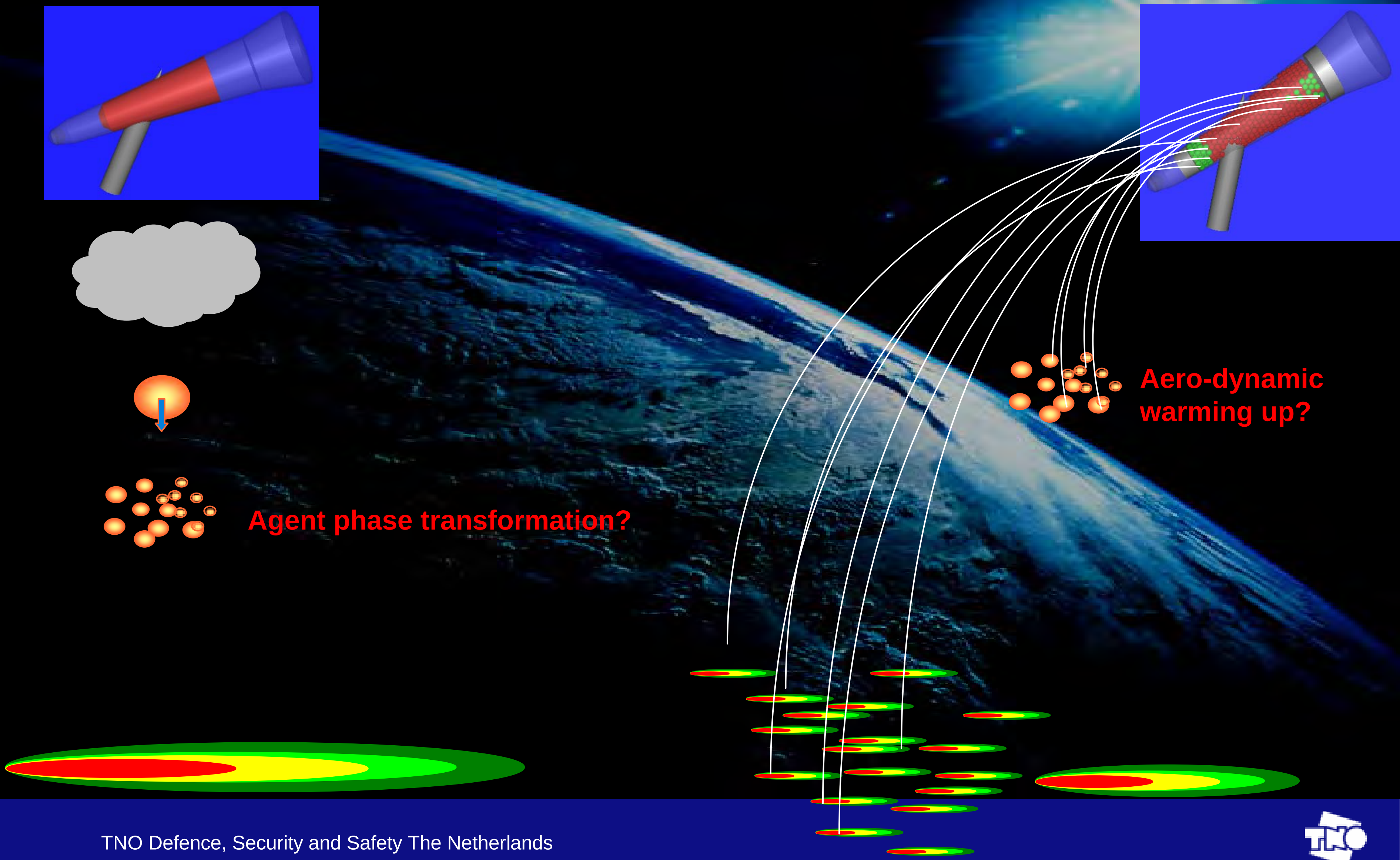
OUTLINE

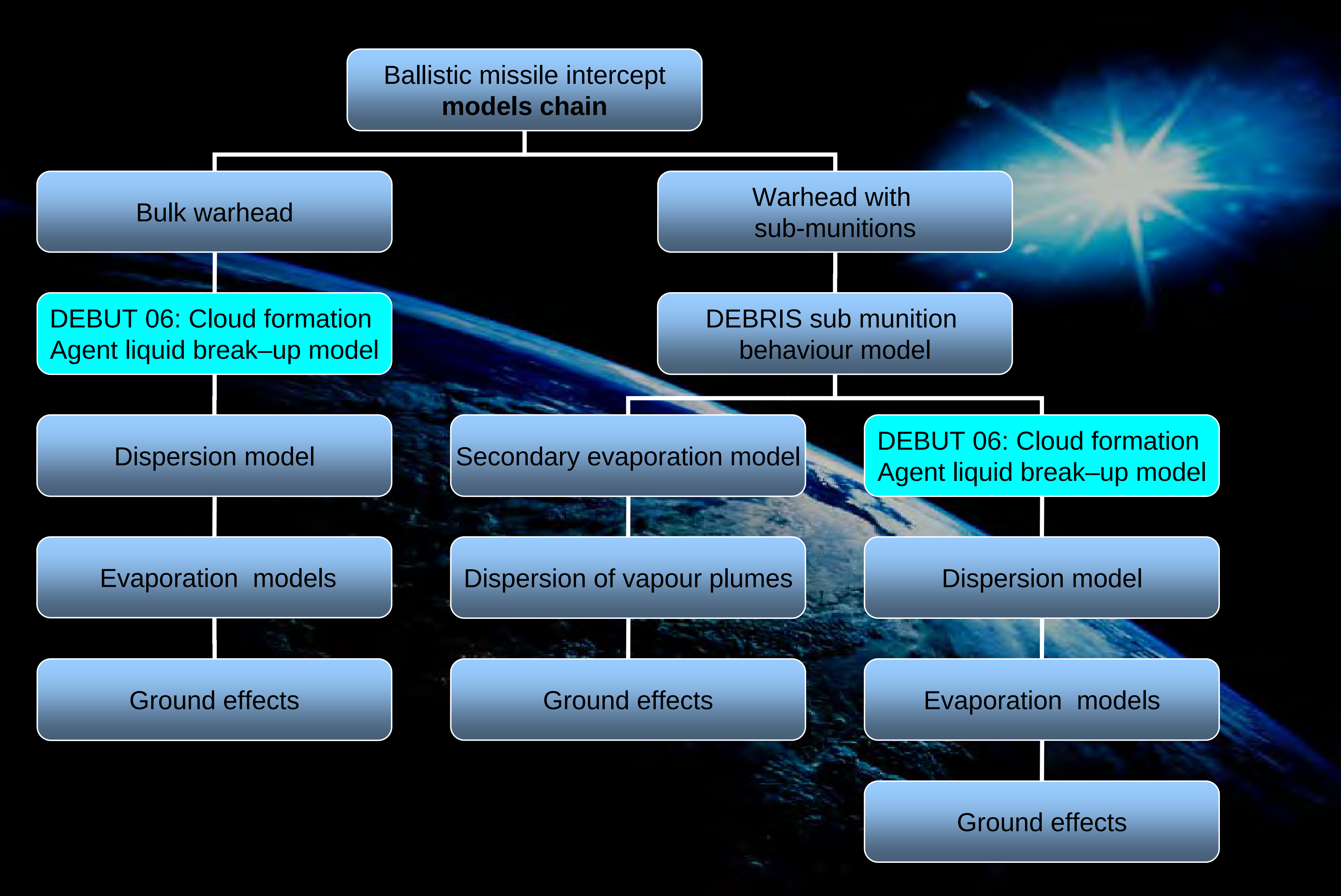
- Introduction
- Description of the models chain – present status
- Development of new sub-models – project in progress
- Applications

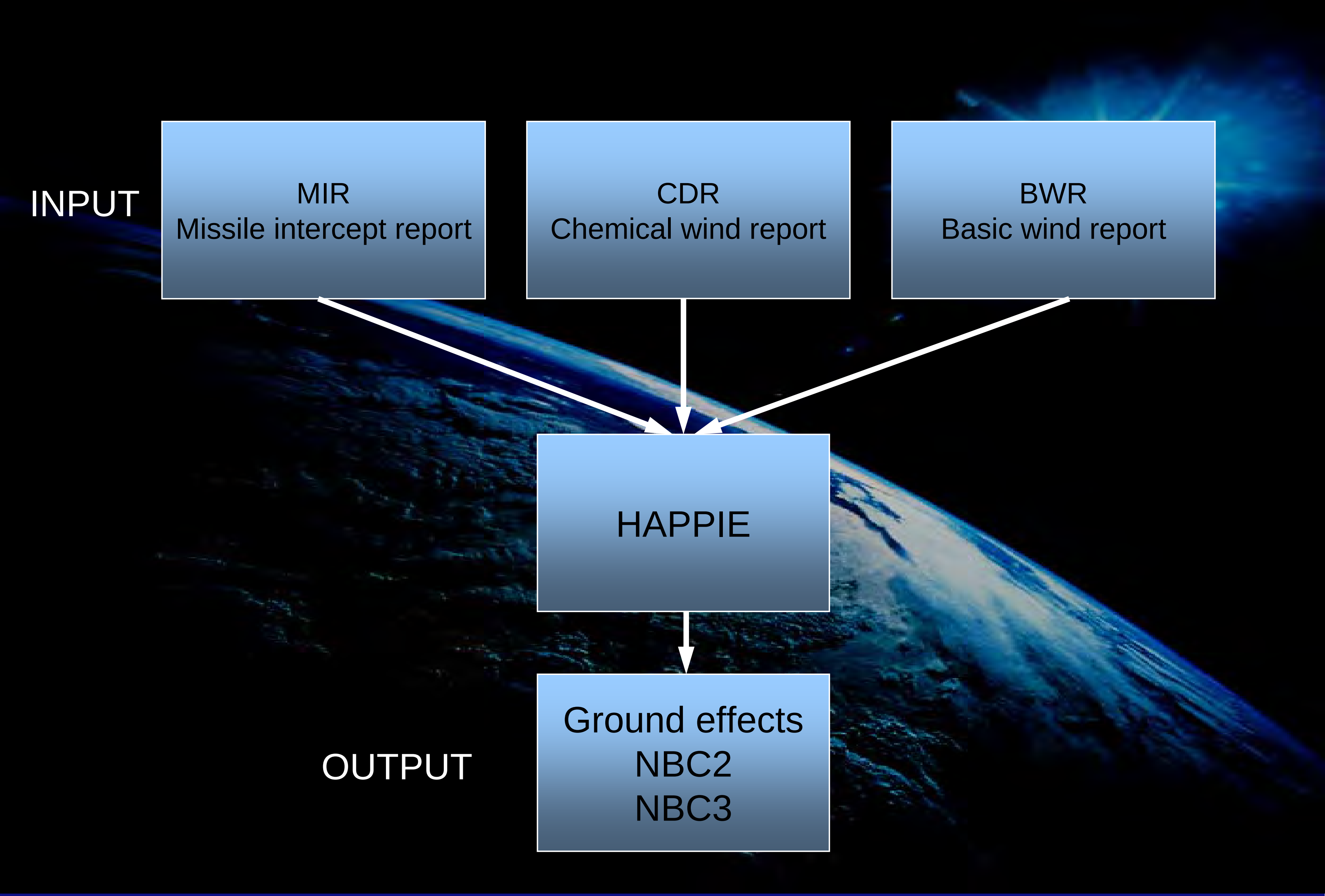
Ballistic missile intercept consequence simulation

Bulk warhead

Warhead with submunitions




Ballistic missile intercept
models chain
Bulk warhead
Warhead with sub-munitions
DEBUT 06: Cloud formation Agent liquid break–up model
DEBRIS sub munition behaviour model
Dispersion model
Secondary evaporation model
DEBUT 06: Cloud formation Agent liquid break–up model
Evaporation models
Dispersion of vapour plumes
Dispersion model
Ground effects
Ground effects
Evaporation models
Ground effects


INPUT
MIR
Missile intercept report
CDR
Chemical wind report
BWR
Basic wind report
HAPPIE
OUTPUT
Ground effects
NBC2
NBC3

Ground effects

- Liquid and vapour deposition patterns

  (probability contour levels)
- Dose ground patterns
- Agent mass recovery on the ground
- Casualty model (available but not included)

Meteo Model

- Monte Carlo procedures simulate the wind direction, the wind speed and the Pasquill class (generate a systematic frequency distribution of the three meteo parameters)
- Sigma=-a*ln(u)+b, gaussian distribution of the wind direction, u is the predicted wind speed
- To generate Meteo conditions we randomly combine: wind speed, wind direction and Pasquill class
- All combinations of Meteo conditions form an ensemble with a representative frequency distribution
- Experimentally validated based on 20 months hourly observations and predictions at 30 meteorological stations

Dispersion model

Puff definition

$$C(x,y,z,t) = m(t) \cdot E_x \cdot E_y \cdot E_z$$

$$E_x = \frac{1}{\sqrt{2\pi} \cdot \sigma_x} \cdot \exp\left(- \frac{(x - x_c)^2}{2\sigma_x^2} \right)$$

C(x, y, z) : mass concentration at location *(x, y, z)*
x_c y_c z_c : co-ordinates of the centre of the puff
m(t) : mass contained in the puff
σ_x σ_y σ_z : standard deviations of the mass distribution

Puff expansion

$$\sigma_{xy} = f(x, a, b, u(z_i))$$

$$\sigma_z = f(x, z_0, c, d)$$

x - travel distance
a,b,c,d – Pasquill stability class dependent constants
u – wind speed at height z_i
z_0 – terrain roughness length

Concentration

$$C(x,y,z,t) = \sum_i C_{puff,i}(x,y,z,t) + \sum_j C_{plume,j}(x,y,z,t)$$

Deposition

$$G(x,y,t) = \int_{-\infty}^{\infty} C(x,y,z,t)\mathrm{d}z$$

Dosage

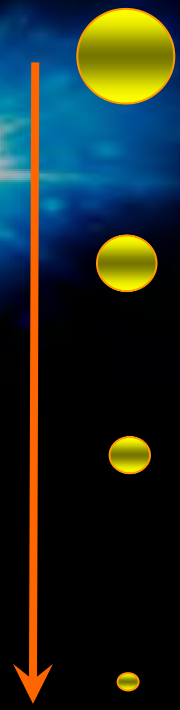
$$D(x,y,z,t) = \int_0^t C(x,y,z,\tau)d\tau$$

Evaporation models

Evaporation of falling drops

$$\frac{dm}{dt} = -2\pi RDShC_S$$

R – drop radius
D – diffusion coefficient
Cs – saturation concentration at Ts
Ts – drop surface temperature



$$Sh, Sc, Nu, \Pr, \mathrm{Re} = f(\eta, k^{air}, c_P^{air}, T^{air}, D, \rho^{air})$$

Secondary evaporation from the surface - the old Monaghan model

$$q_1 = m_i \cdot \frac{1 - f_{ss}}{t_{ss} - t_{imp}}$$

$$q_2 = m_i \cdot \frac{f_{ss} - f_{te}}{t_{te} - t_{ss}}$$

$$q_3 = 0$$

q_1, q_2, q_3 - evaporation rates in the three phases

f_{imp} - remaining liquid fraction at drop's impact time
f_{ss} - at drop's steady state time
f_{te} - at the total evaporation time

DEBRIS submunition behaviour model

- Trajectory analysis

- Aerodynamic heating of the submunitions:

  - Shape and material of the submunition
  - Available thermal protection coating
  - Type of the agent
  - Ejection velocity
  - Height of release

- Heating and thermal demise of agent contained in the submunition

  - Convection model
  - Agent properties studies

Break-up model – in progress

DEBUT 06: Drop Evaporation and Break-Up Tool

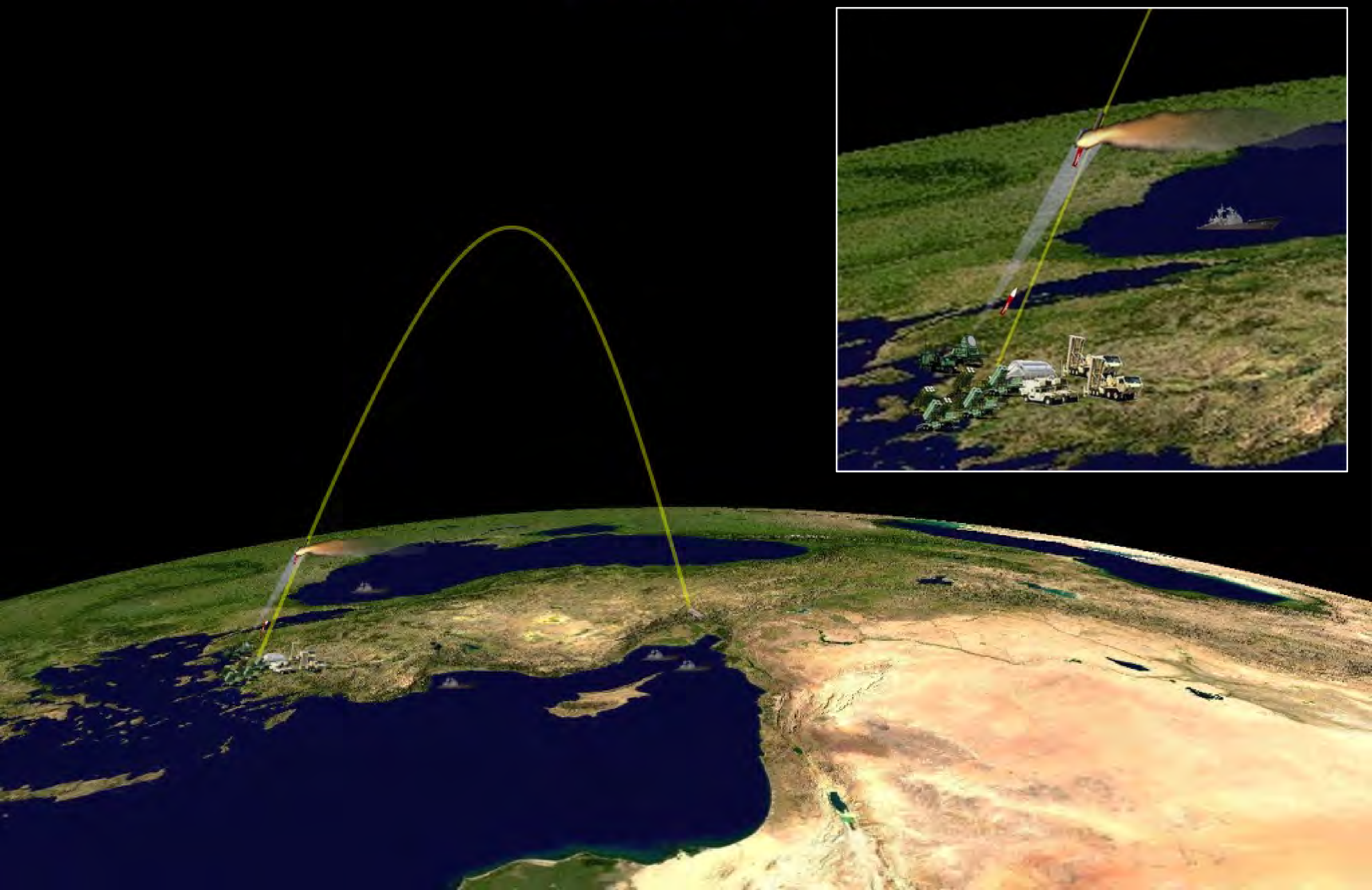
It calculates:

- Agent cloud dimensions
- Drop size distributions
- Initial mass loss due to evaporation
- Validation on-going (experiments due in 2007 / 2008)

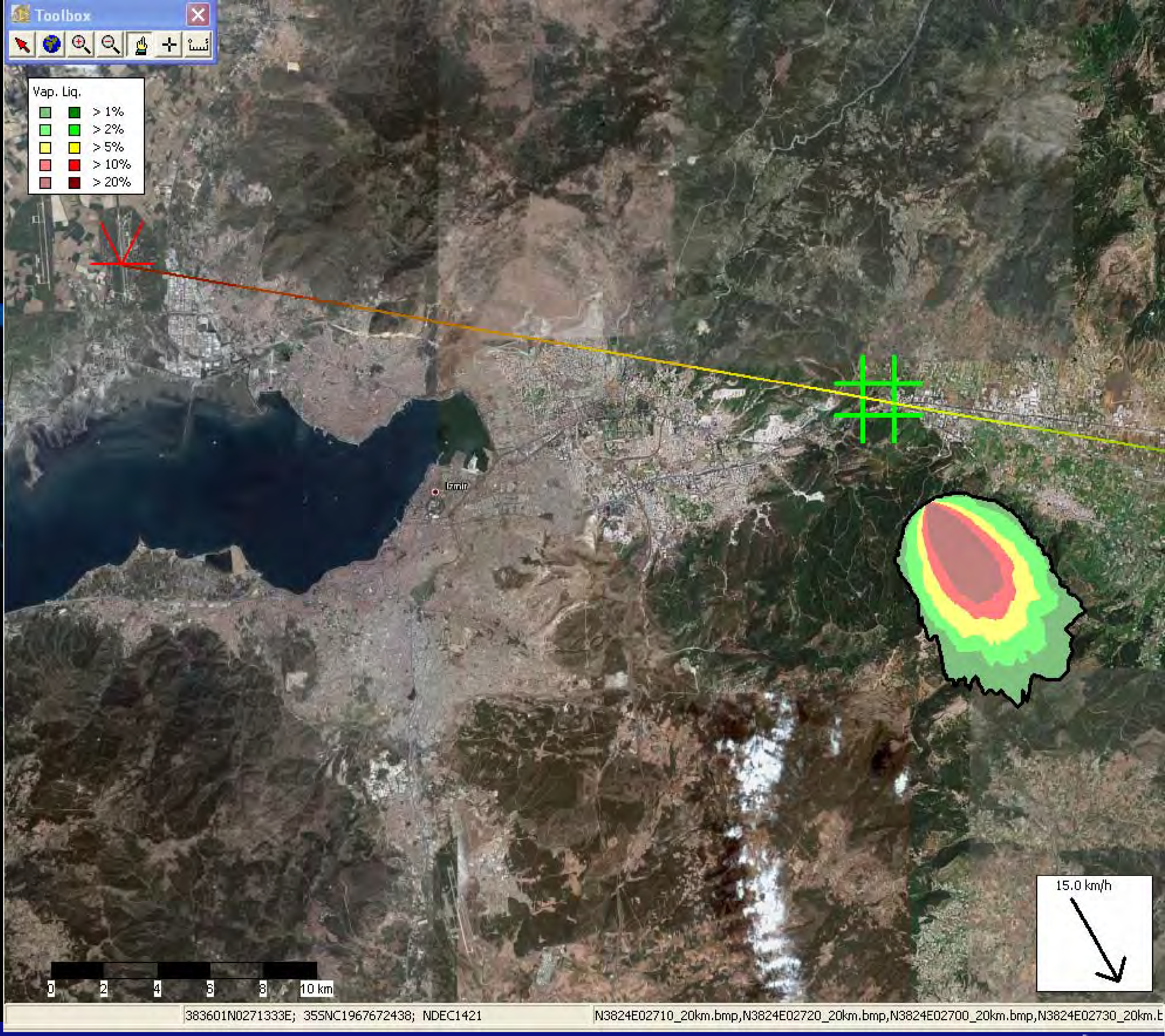
To be developed also for non-Newtonian liquids

HAPPIE in JPOW IX 2006

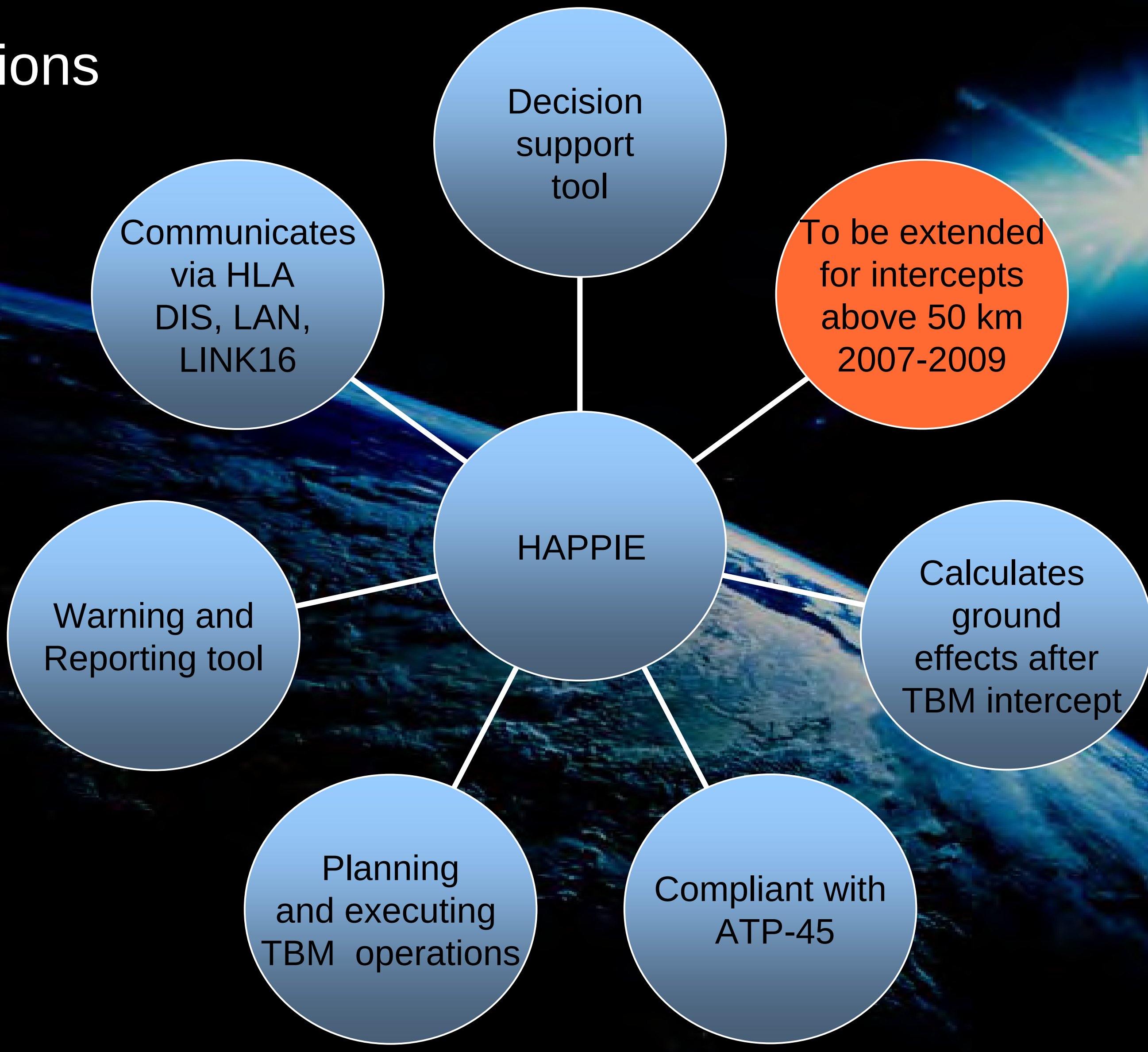
An missile intercept exercise performed within JPOW IX



Ground effect calculation after an missile intercept performed within JPOW IX



Applications



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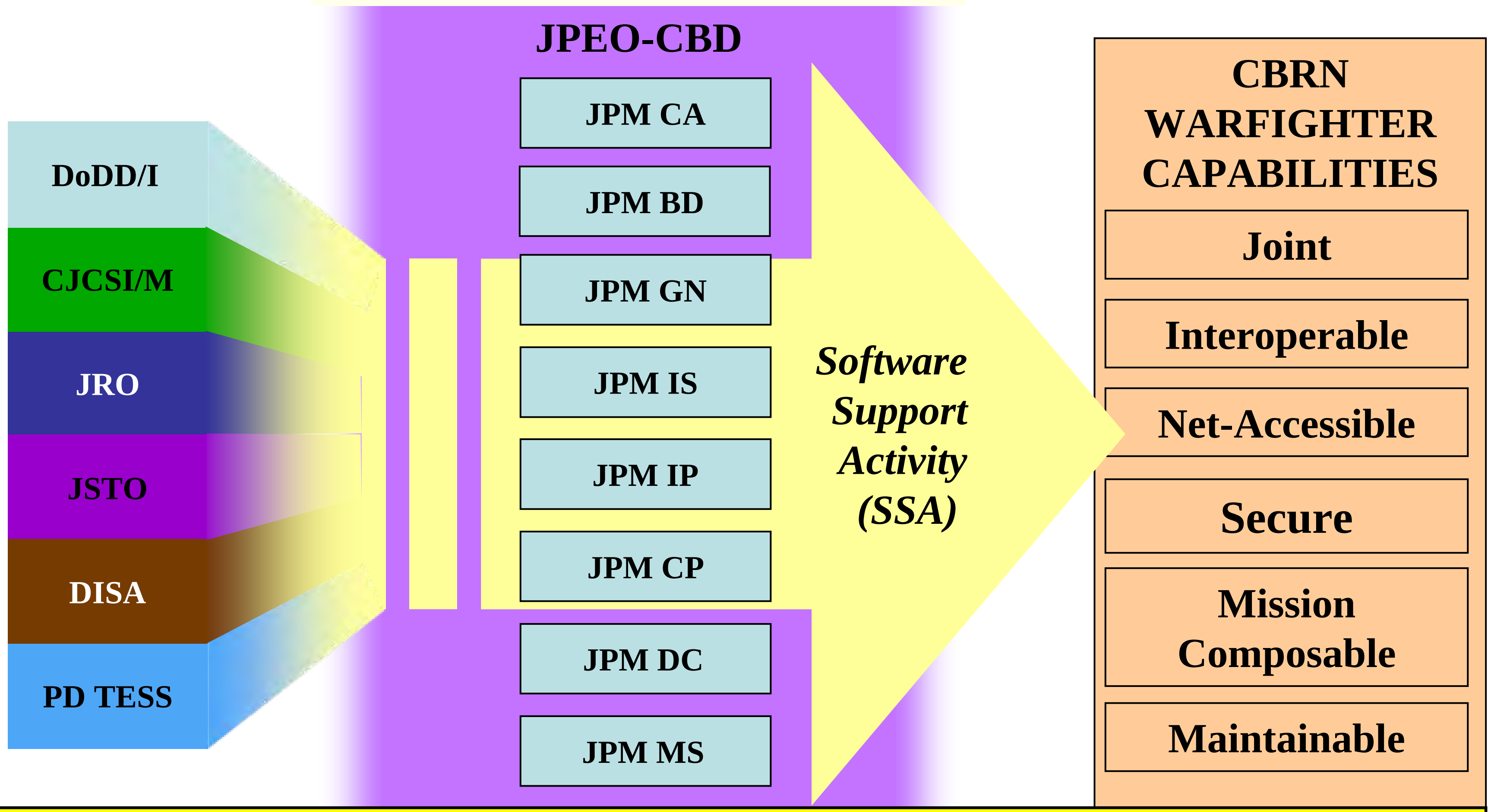
JPEO CBD
Software Support Activity
(Net-Centric Services)
January 9, 2007

Kevin Adams
Chief, Future Technologies
SSA Director
kevin.adams@jpmis.mil

Agenda

1. SSA Overview
2. GIG and Net-Centric Issues
   – C2 Transition to SOA
   – Migration Strategy
3. How Do We Meet the Challenge
4. Leveraging Activities
5. Road Ahead

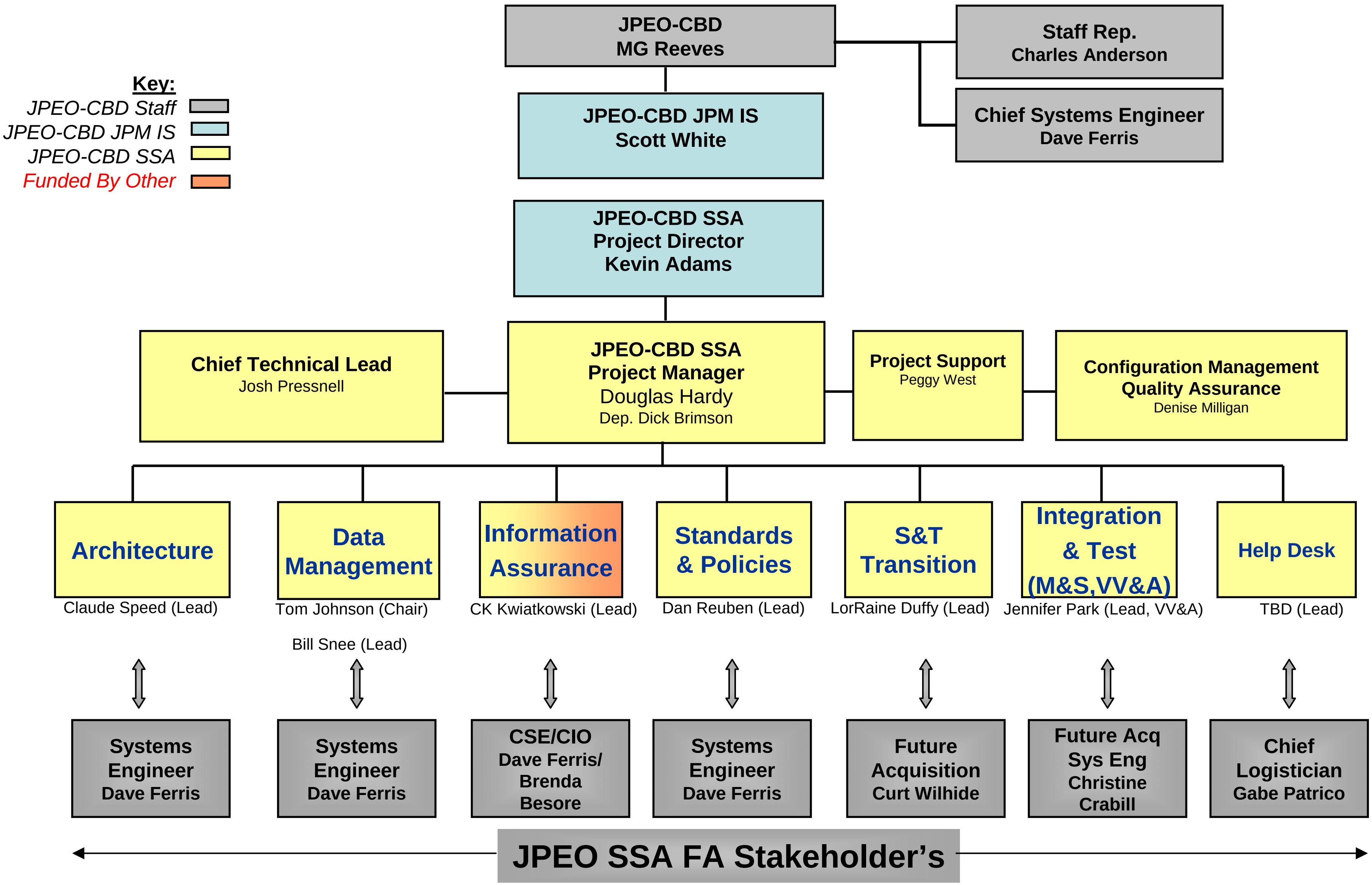
CBRN-SSA Vision



SSA WORKS TO REALIZE THE VISION OF NET-CENTRIC WARFARE -

Cost effective single point of contact for users (Customers, Developers, and Warfighters) to receive professional and timely assistance with all CBRN Defense program standards, interoperability, and supportability needs to ultimately facilitate the creation of more efficient, common, and consistently superior *interoperable and integrated* CBRN systems.

SSA FY07 Organization



GIG Compliance

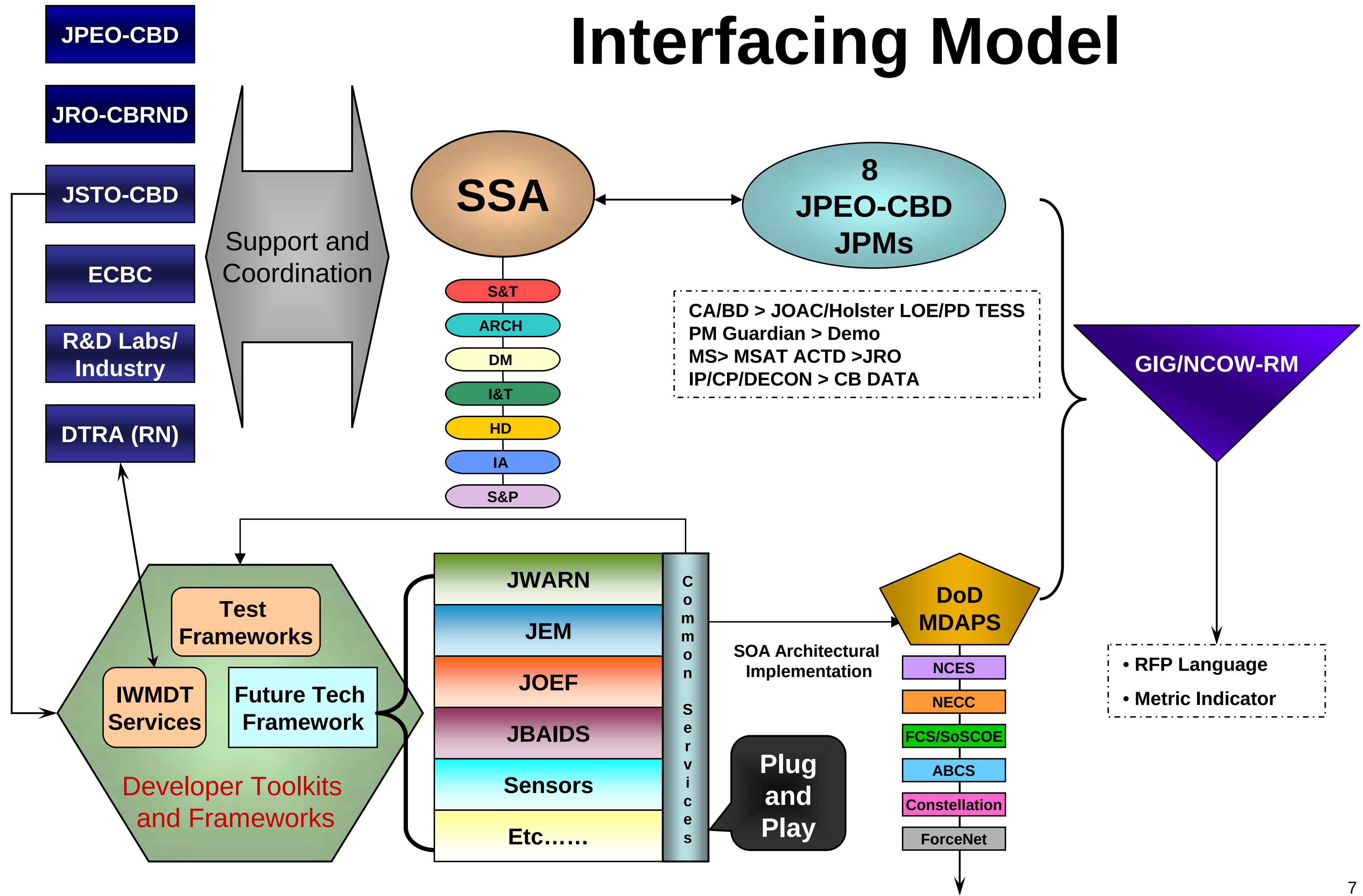
- Compliance with the GIG means an information technology-based initiative or an acquisition program, throughout its lifecycle:
- Meets the DoD Architecture Framework (DoDAF) requirements.
- Meets the Core Architecture Data Model (CADM) requirements for using/reusing architecture data.
- Meets the DoD Information Technology Standards Registry (DISR) requirements in selecting technologies and standards.
- Meets the DoD Net-Centric Data Strategy requirements and intent.
- Explicitly addresses net-centricity and determine the program's net-centric correspondence to key net-centric criteria (e.g., concepts, processes, services, technologies, standards, and taxonomy). (For further information see the Net-Centric Operations and Warfare Reference Model (NCOW RM) Compliance Assessment Methodology (Draft) - found on the GIG Architecture website).
- Meets the broad requirements set forth in the GIG Capstone Requirements Document.

*NCOW RM

- The NCOW RM is focused on achieving net-centricity. Compliance with the NCOW RM translates to articulating how each program approaches and implements net-centric features. Compliance does not require separate documentation; rather, it requires that program managers and Sponsors/Domain Owners address, within existing architecture, analysis, and program architecture documentation, the issues identified by using the model, and further, that they make explicit the path to net-centricity the program is taking.

*Net-Centric Operational Warfare Reference Model

Net-Centric Interfacing Model



Net-Centricity – What We Need to Know

- Each of the Services are migrating to SOA
  - ForceNet, FCS/SoSCOE, and Army Enterprise Architecture (AEA), Constellation NECC/NCES
- Enterprise Services are being defined
  - Data
  - Security
  - User interfacing standardization
- CBRN capabilities need to be modular and plug into various networks easily
  - Plug and Play
  - Composeable
  - Scalable
- MDAP will drive the Architecture
  - C2 Systems will have open Architecture and Standards

MDAP Integration

Will require expertise and understanding of the following:

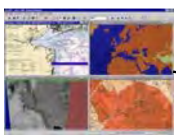
- Systems and Software Analysis, Architecture, Engineering, and Evaluation
- Networking of Sensors and Systems
- Distributed Web-Based Sensors
- Net-centric computing and network algorithms
- CBRN Sensor Emulation
- C4ISR / C2
- Data Modeling (CBRN Data Model and XML Schema)
- Service Oriented Architectures
- Expert Systems, Intelligent Agents, Distributed and Parallel Computing
- Embedded systems
- Real-Time Systems
- Networked Communications (wireless and wired)
- Modeling and Simulation (Expertise, Tools, Technology, Frameworks, Standards)
- Information Assurance Planning, Strategies, Process, Policy and Execution, and System Security Accreditations
- Standards and Interfaces for Models, Information Systems, and Sensors

How Do We Meet the Challenge?

Joint Integrated Modular Mission Configurable Networked CBRN Capabilities

CBRN-Enabled GIG via CBRN IS

Networked CBRN Net-Centric COPs enabled by JPM Information Systems, NCES and NECC…



CBRN Warning, Reporting, Alerting, Plans, Course of Action, CBRN Status and Readiness

01 10 01 10 01 10 01 10 01 10 01 10 01 10 01 10 01 10 01 10 01 10 01 10 01 10 01 10

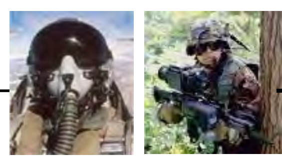
GIG

HHQ / Strategic

Installations

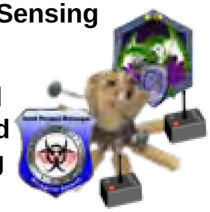
Afloat (DDX)

Tactical Units (FCS)



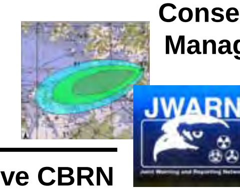
Warfighter

CBRN Sensing



Fixed, mobile, and platform embedded Integrated sensing capabilities

Integrated Warning and Reporting, Hazard Prediction, Course of Action, and Consequence Management



Pervasive CBRN Networked Intel

CBRN Medical Treatment

Prophylaxis and triage

DECON

Remove the threat, preserve the Warfighter and the Equipment

Integrated Protection for Installations, Units, and Vehicles on the move

Chemical Biological Radiological Collective Protection Joint Program

Individual Protection

Continued CBRN-Protected Individual Mission Execution

CBRN Defense Capabilities Required at all Echelons and on all Platforms for Mission Effectiveness!

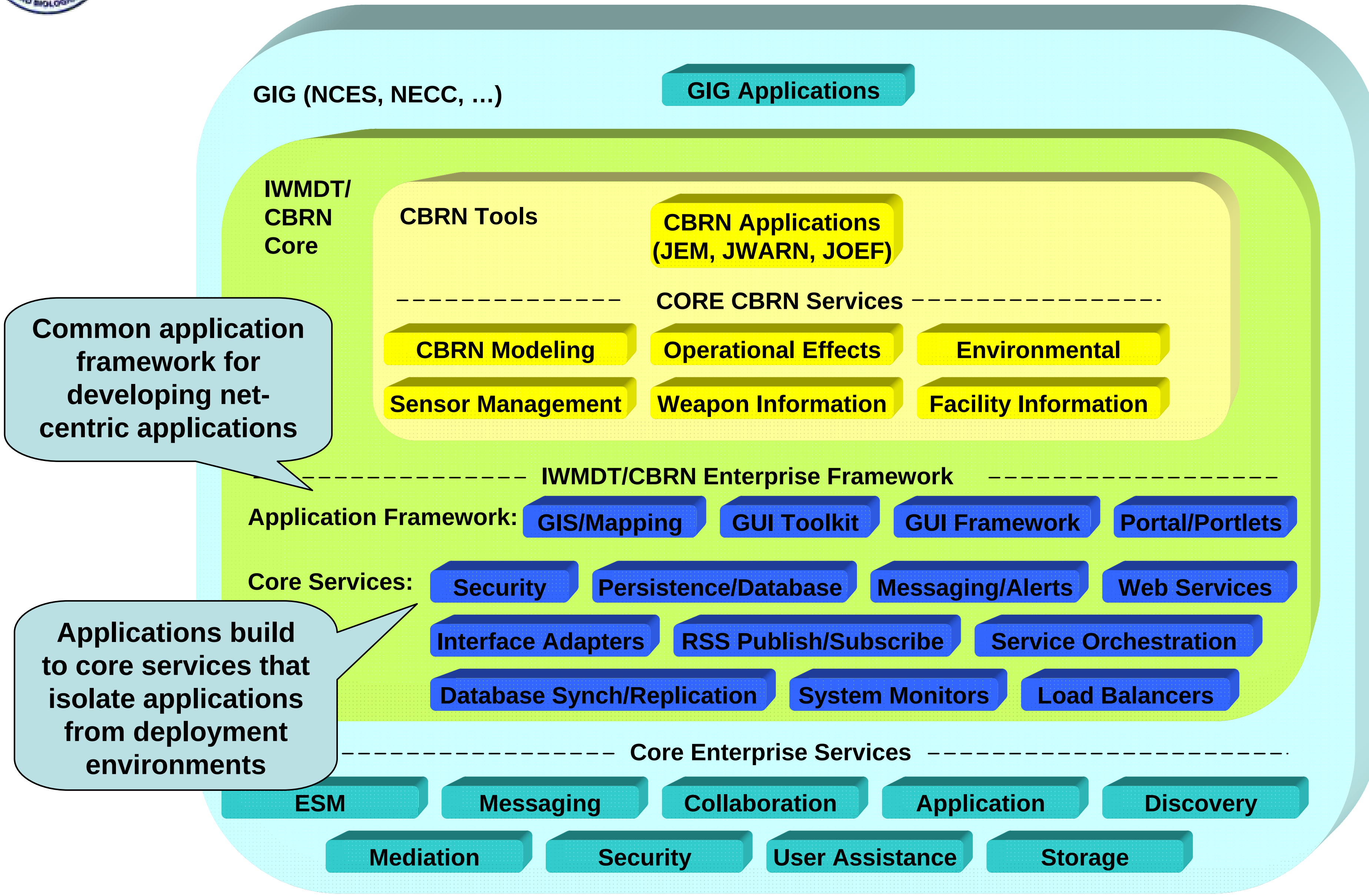
CBRN Data Model Supports Net-Centric Data Strategy

- **Enables the grouping of services to create a system of systems**
- **Defines common data elements when creating a web service**
- **Used to make CBRN data discoverable and accessible**
- **Eliminates point-to-point interface development**
- **Used to Create the CBRN XML Schema**
- **Reusable data definitions**
- **Shortens System Development Time**
- **Facilitates Reuse of System Components**
- **Allows for investment in component improvement versus component reinvention**
- **Requires sustainment under POR purview**

Current S&T Efforts Supporting Common Services

- JSTO Sponsored Shared Common Operating Picture (COP) for HLS and HLD
  - Integrated shared COP capabilities for HLS/HLD
    - Mostly message integration
    - JEM proxy
  - Currently in phase 2
- JSTO Sponsored Common CBRN Software Services
  - A common framework to support Net-Centric Components and Services environments.
    - NCES, NECC, SoSCOE, ForceNet e.g.
- NECC & NCES pilots
  - Awaiting Approval
- Program risk reduction pilots and LOEs
  - JCID on a Chip (JoaC)
  - COE decoupling pilots
  - Technical decision pilots
  - Holster LOE (JPEO-CBD initiative)

Proposed Leveraging Activities - Tech Base Architecture

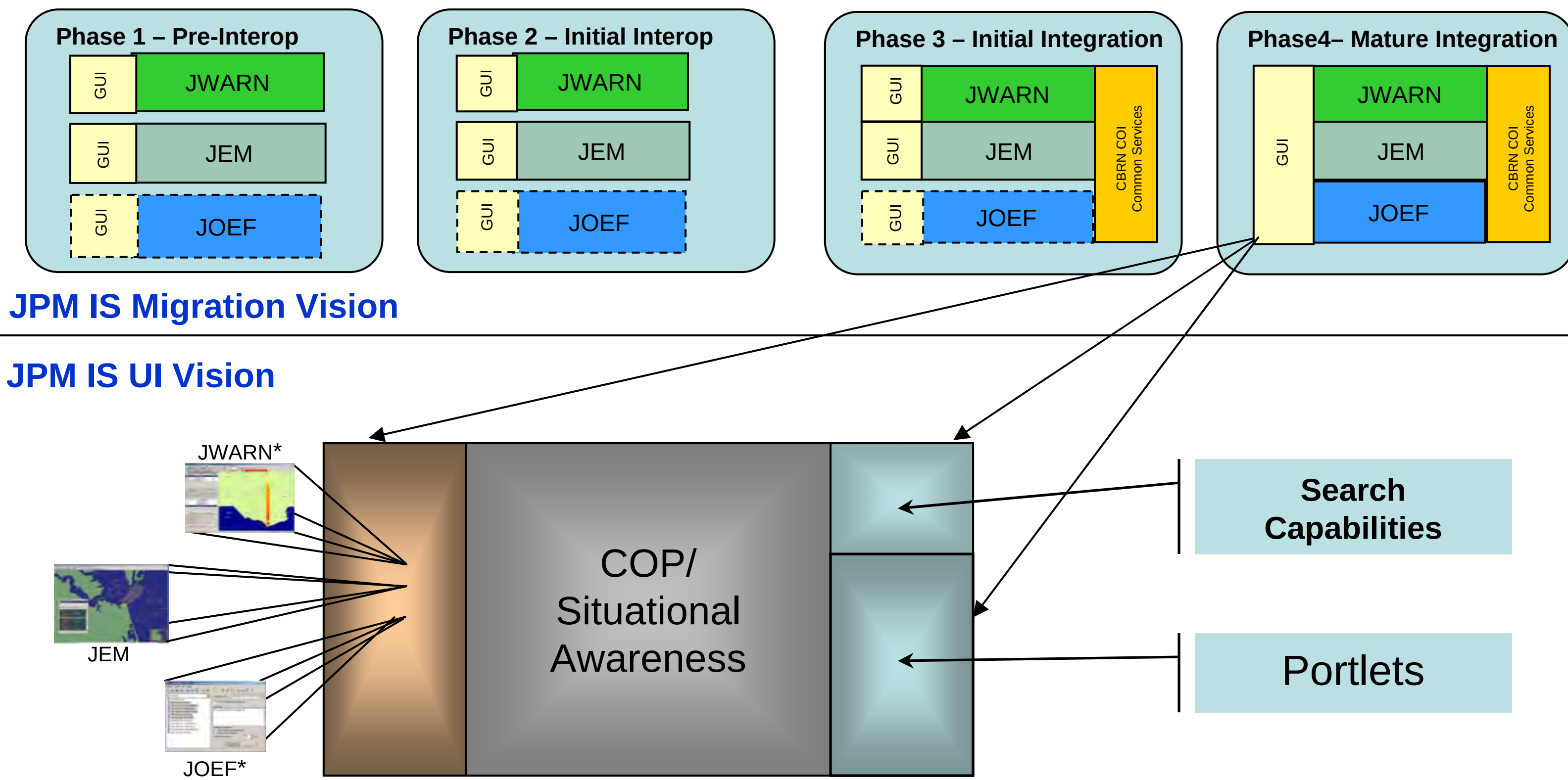


Leveraging JPM IS Integrated Product Vision

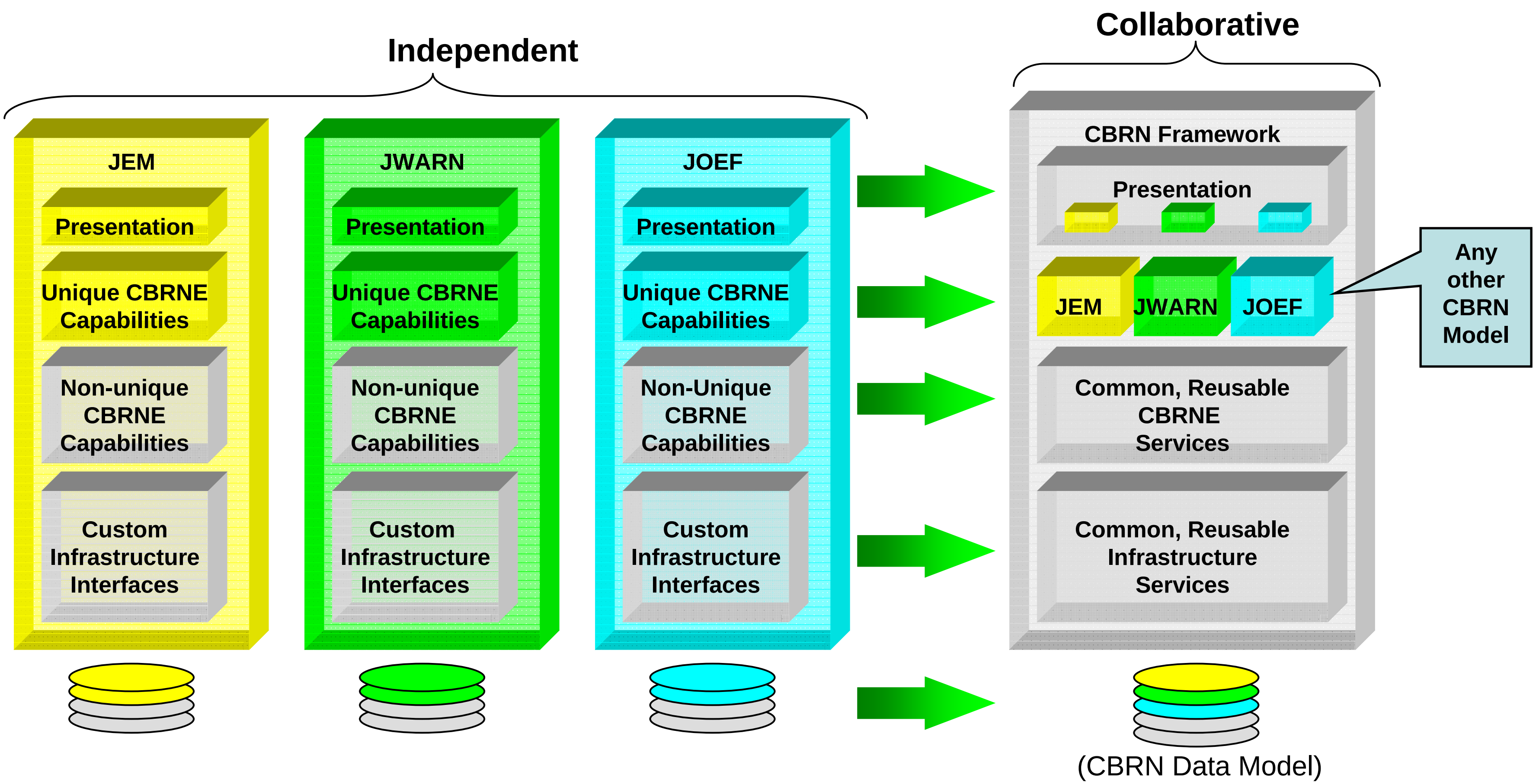
Provide CBRN products in a timely and efficient manner to the warfighter and first responder

- **Integrated family of products**
- **Single integrated user interface to all services**

Integration/Interoperability Path to NCES/JC2



Maximize Re-Use at all Levels



Road Ahead for a Common CBRN Framework

- **Review Message Sharing Requirements**
  - **Mediation service for Message conversion**
  - **Architecture for message converters and parsers**
- **Implement a Common GIS Framework**
  - **Same code base to; WebCOP, C2PC, Googlemaps, JWC.**
- **Put in Place an Open Architecture Approach to Integration**
  - **Allows decoupled messaging**
  - **Middleware agnostic**
  - **Insulation of program development cycles from others**
- **Open Architecture approach for Sensor Integration**
  - **Common front end to JWARN to allow multiple sensor networks**
- **Support Common Net-Centric Services**

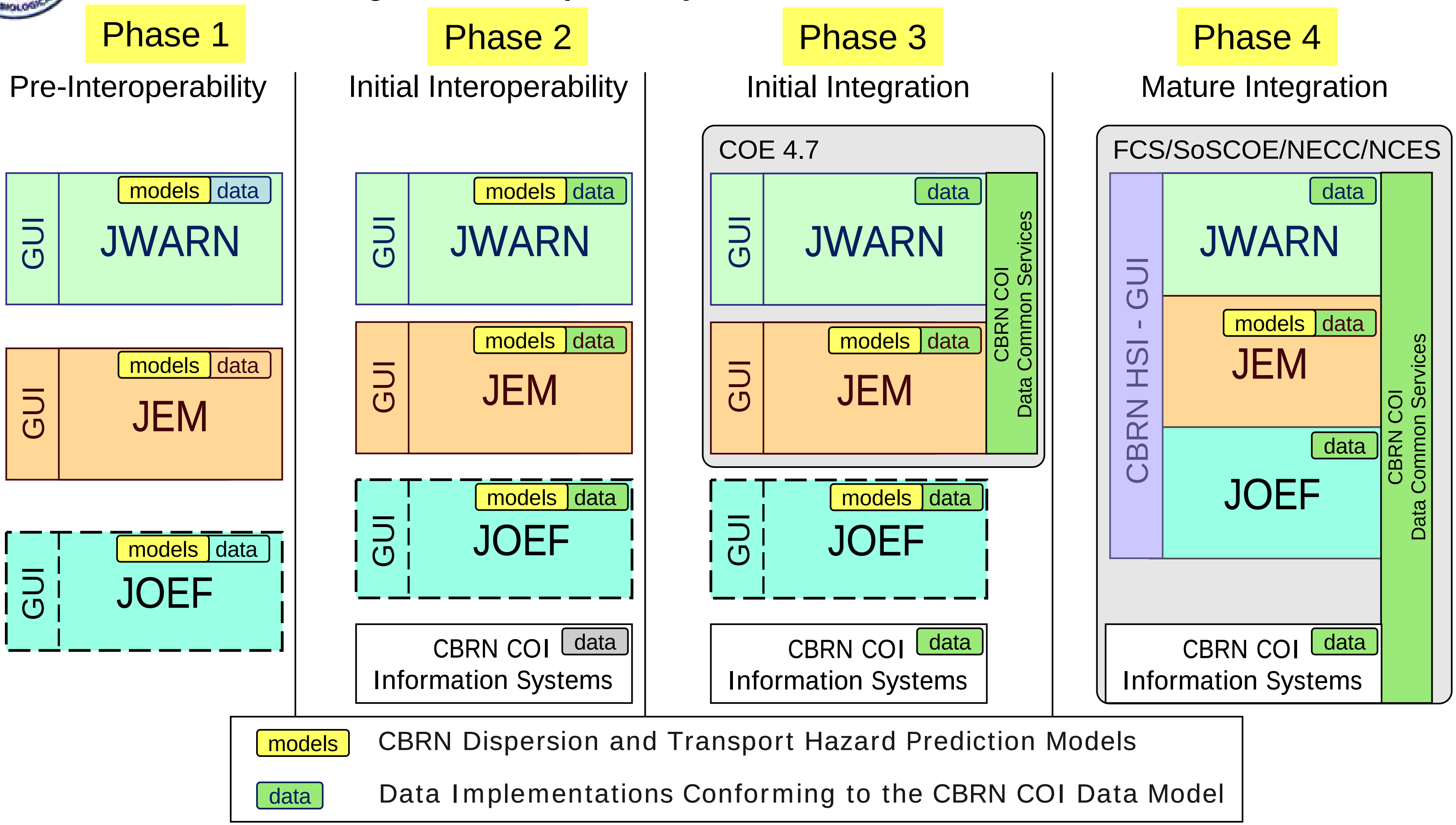
SSA Goals

- **Need to reduce lifecycle cost of JPEO-CBD products and artifacts as they relate to MDAP integration and interoperability.**
- **Increase collaboration and coordination in the CBRN development community.**
- **Maximize flexibility, reuse, and portability of software components.**
- **Reduce interfacing (outward looking) software for each POR.**
- **Align Tech Base under a SOA to transition to the user/warfighter product faster and cheaper.**

Impacts SENSE/SHAPE/SHIELD/SUSTAIN

BACKUPS

JPM IS Migration Strategy
Integration/Interoperability Path to FCS/NCES/NECC/Etc.

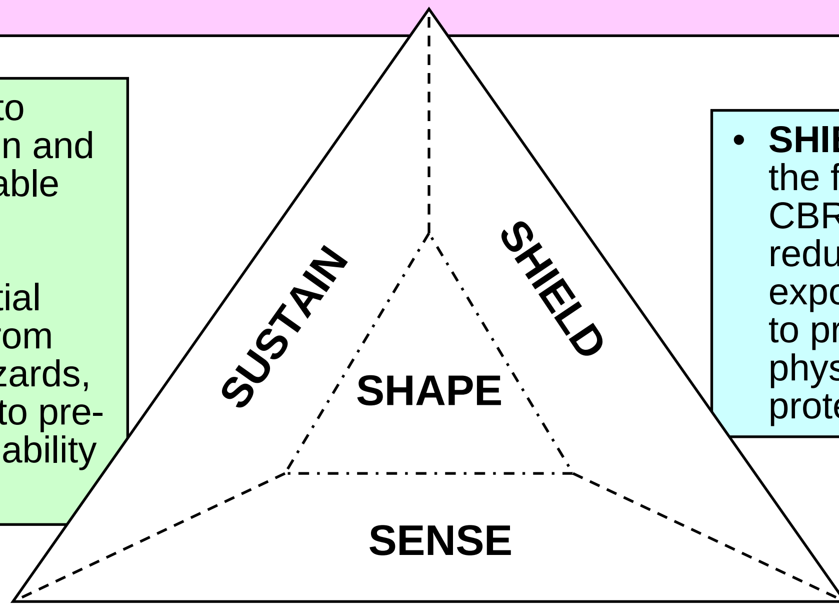


ARCHITECTURE MIGRATION STRATEGY - *DISCIPLINED EVOLUTION OF DESIGN TO MEET THE VISION!*

Joint CBRN Defense Functional Concept

- **SHAPE –** Provides the ability to characterize the CBRN hazard to the force commander - develop a clear understanding of the current and predicted CBRN situation; collect and assimilate info from sensors, intelligence, medical, etc., in near real time to inform personnel, provide actual and potential impacts of CBRN hazards; envision critical SENSE, SHIELD and SUSTAIN end states (preparation for operations); visualize the sequence of events that moves the force from its current state to those end states.

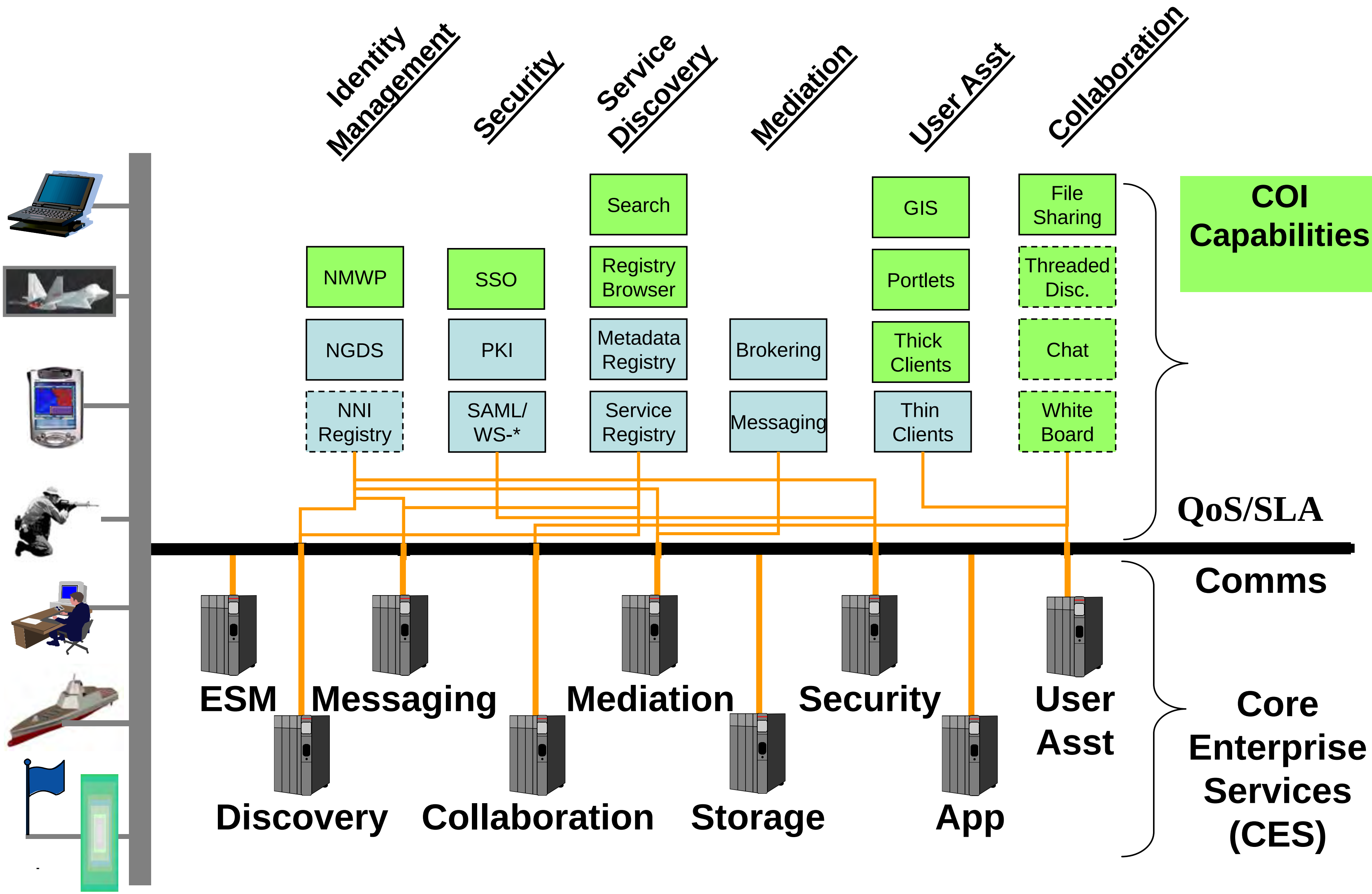
- **SUSTAIN –** The ability to conduct decontamination and medical actions that enable the quick restoration of combat power, maintain/recover essential functions that are free from the effects of CBRN hazards, and facilitate the return to pre-incident operational capability as soon as possible.



- **SHIELD –**The capability to shield the force from harm caused by CBRN hazards by preventing or reducing individual and collective exposures, applying prophylaxis to prevent or mitigate negative physiological effects, and protecting critical equipment

- **SENSE – The capability to continually provide the information about the CBRN situation at a time and place by detecting, identifying, and quantifying CBRN hazards in air, water, on land, on personnel, equipment or facilities. This capability includes detecting, identifying, and quantifying those CBRN hazards in all physical states (solid, liquid, gas).**

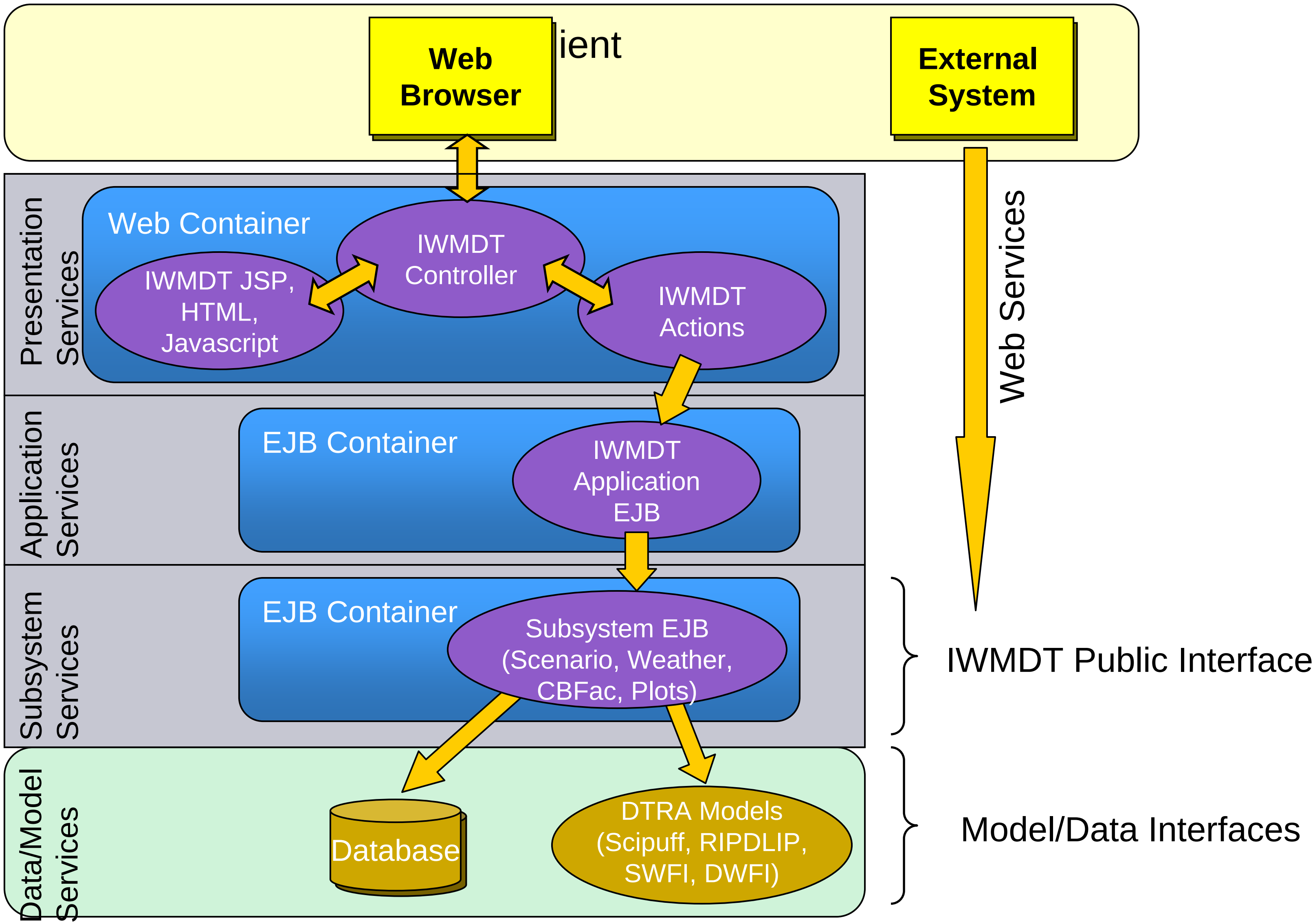
TO - BE


Identity Management
Security
Service Discovery
Mediation
User Asst
Collaboration
Search
GIS
File Sharing
COI Capabilities
NMWP
SSO
Registry Browser
Portlets
Threaded Disc.
NGDS
PKI
Metadata Registry
Brokering
Thick Clients
Chat
NNI Registry
SAML/ WS-*
Service Registry
Messaging
Thin Clients
White Board
QoS/SLA
Comms
ESM
Messaging
Mediation
Security
User Asst
Discovery
Collaboration
Storage
App
Core Enterprise Services (CES)

DoD Current Activities

- GIS interoperability
  - GIS applications availability via common open standards (OGC)
    - GIS targets
      - FalconView, Joint WebCOP(JWC), OSWebCOP, Joint Battlespace Viewer (JBV), googleMap, GoogleEarth, C2PC
- COE migration to SOA's
  - Messaging
    - Using Exchange and outlook plugins from DMS program to bridge from COE to COTS
    - Migrate off CMP and UCP
  - Publish/Subscribe
    - Leveraging current GCCS-M initiatives like Joint translator forwarder(JXF).
    - Asynchronous messaging using JMS and the BEAWLS segments
    - RT Bridges - NDDS, OMG-DDS, SPLICE
  - Registry/directory for lookups
    - Active Directory to LDAP configurations for finding services and enterprise management of users and applications
    - NCES Service discovery and Service Registry (UDDI)

IWMDT Software Architecture Layers



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Decision Aids for CBRN Investment Planning & Analysis

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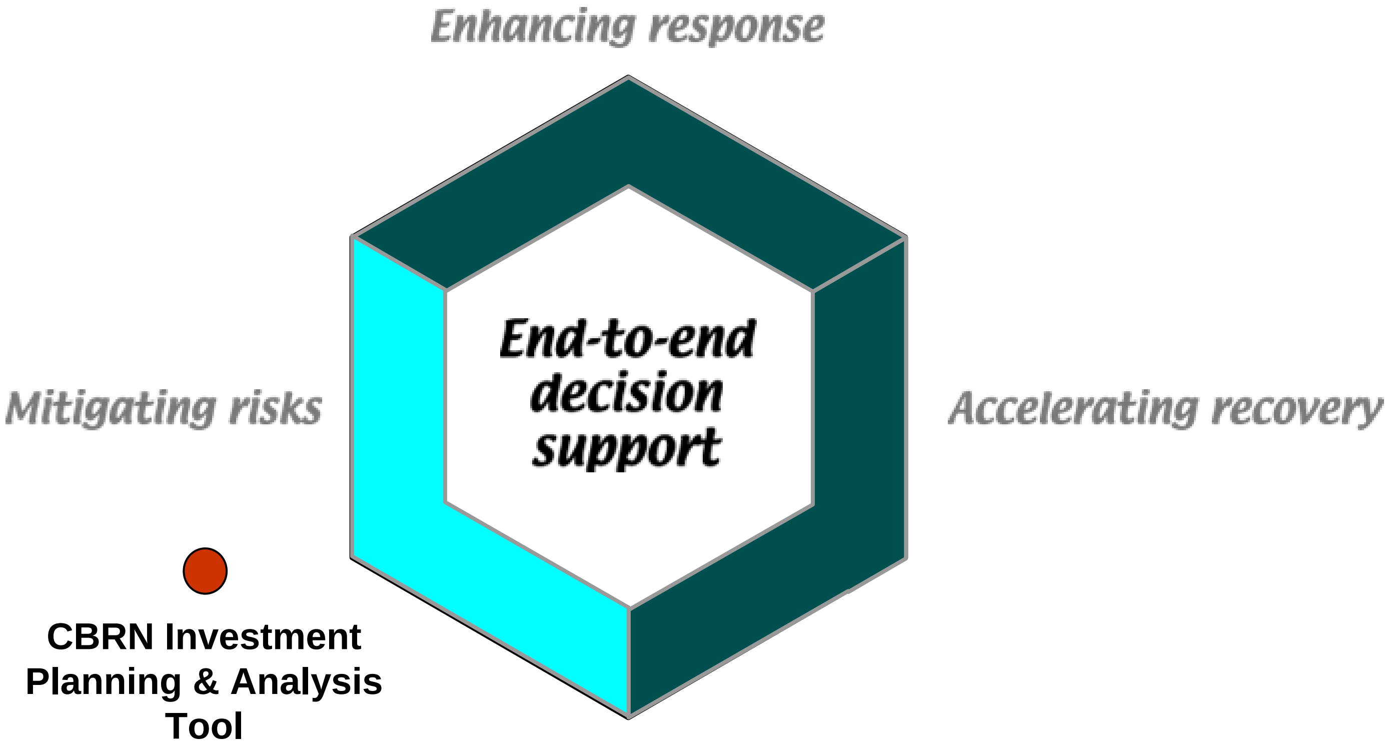
Sandia National Laboratories

Agenda

- End-to-end decision support context
- Investment planning & analysis for CBRN Defense Architectures
  - Problem motivation
  - Analysis questions
  - Challenges
- CBRN Investment Planning & Analysis Tool project
  - Overview
  - Program manager support
  - Foundational capabilities
- Leveraged capabilities
  - BioDAC
  - Knowledge elicitation and domain expertise
  - DAKOTA
  - MIDST
- Summary

Pre-event planning is a critical component of end-to-end decision support for CB events.



Procurement and deployment of CBRN defense architectures requires understanding and evaluation of complex option space.

DoD program managers and installation planners must:

- Procure, deploy, and refresh chemical, biological, radiological, and nuclear (CBRN) detection, response, mitigation, and restoration capabilities to protect the warfighter and DoD installations/critical assets
- Effectively analyze and quantify the system effectiveness of these defensive architectures against a CBRN threat spectrum
- Determine requirements for future capabilities to meet evolving mission needs

All within limited budgets!

Example: Guardian Installation Protection Program

Investment analysis questions extend beyond technology effectiveness tradeoffs and can be asked for both procurement and R&D.

Procurement analysis questions:

- Given a fixed budget for procurement and annual O&M, what investments would be recommended in detection and response technologies for a given suite of threat scenarios?
- What technologies are required to meet specified minimum damage and casualty or mission capability thresholds?
- How can the critical assets/mission capabilities on an installation be best protected, taking into account resources available across the entire base?
- If a civilian detection and response capability exists proximate to a military installation, what detection, protection, and/or response technologies should be purchased and how should it be deployed to protect the venue? What impact will the CONOPS and information sharing across civilian/military communities have on the effectiveness of this architecture?

R&D analysis questions:

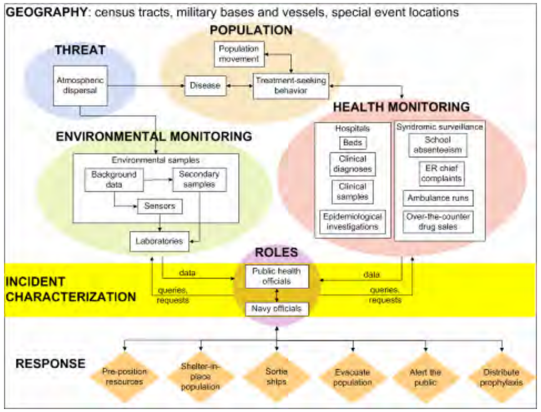
- What sensor system research investment strategy is most cost effective (over the lifetime of the sensors) in detecting a given suite of chemical, biological, or radiological/nuclear attacks?
- Given a spectrum of detection and response technology investment options and associated research risks, which combination of investments is most likely to meet specified detection and/or response thresholds for a given suite of WMD attacks?

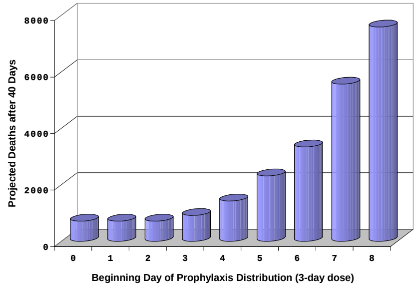
Challenges in addressing and answering investment questions must encompass technical and human factors and address uncertainty.

- Complexity of trade-off space
  - Threat types, threat scenarios, environments, technologies, CONOPS, etc.
- Developing meaningful, vetted performance assessments
  - Technology (e.g., sensors, protective gear, comms, etc.)
  - Operations
  - Integrated defensive architecture
- Defining measures of system effectiveness
  - Ability to complete mission
  - Morbidity and mortality
  - Loss of critical assets
- Characterizing and quantifying effects of uncertainty
  - Aleatory – irreducible uncertainty due to inherent (stochastic) properties
  - Epistemic – subjective uncertainty due to lack of knowledge

The CBRN Investment Planning & Analysis Tool (IPAT) project will develop methods and software to support investment decisions.

- FY07 new-start project funded through DTRA JSTO (M/S Battlespace, Decision Support)
- Develop knowledge elicitation, quantification, and representation techniques to capture and represent attack scenarios, defensive technologies and CONOPS, and site characteristics
- Meld scenario-based WMD attack models with computer codes supporting "what-if" trade-offs and sensitivity analysis capabilities to understand uncertainties

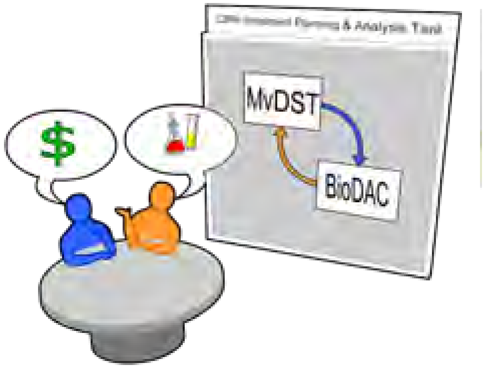




Mitigating risks

The CBRN IPAT project is targeting the Guardian Installation Protection Program decision makers.

The CBRN Investment Planning & Analysis Tool (CBRN IPAT) will enable automated, transparent, standardized cost/benefit analyses of CBRN defense architectures.

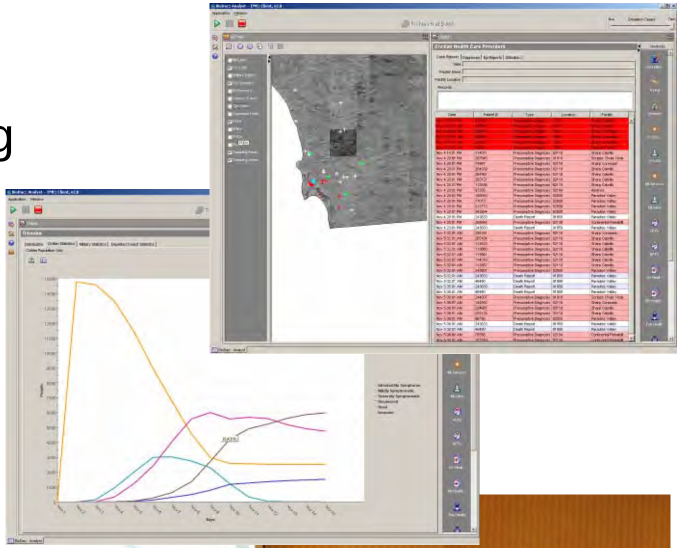


The CBRN IPAT will support installation protection investment decisions through:

- Methods and tools for assessing measures of effectiveness
  - Formulating performance and effectiveness measures and metrics
  - Comparing the potential impact of different procurement options on CBRN architecture effectiveness across a multitude of attack scenarios
  - Identifying gaps and impact of new capabilities
- Methods and tools for capturing and quantifying uncertainties
  - Approaches for handling aleatory and epistemic uncertainty
  - Assessing the sensitivity of the analysis results to variations in threat scenarios, technology performance, and other architecture factors

CBRN IPAT development will leverage CBRN domain expertise, knowledge elicitation and representation, and M&S capabilities developed through DHS, DoD, and DOE.

- Existing methods, tools, and applicable CBRN domain expertise will be leveraged to support the IPAT analysis methodology and supporting software. These capabilities include:
  - Conceptual models for CBRN events and response timelines
  - CBRN defense analysis tools (e.g., BioDAC)
  - Optimization, uncertainty quantification and sensitivity analysis libraries (DAKOTA)
  - Systems and numerical analysis experience



- In addition, Sandia will partner with the DTRA University Partnership Gold Team to:
  - Share research in multivariate decision support algorithms
  - Provide bi-directional data feeds between IPAT and the Multivariate Investment Decision Support Tool (MIDST)

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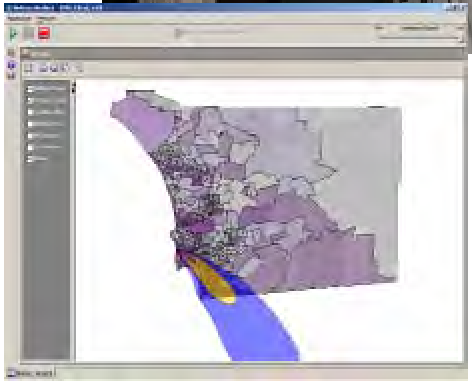
Mitigating risks

BioDAC allows systems analysis of defensive architectures in bio-attack scenarios to evaluate system effectiveness

The BioNet program (2005-2006) integrated and enhanced civilian and military capabilities to detect and characterize a bioattack in an urban area.

Developed through the BioNet program, the Biological Decision Analysis Center (BioDAC) simulation tool:

- Models system-level performance of bio-defense architectures in a major urban area
- Calculates simulation results for bio-attack scenarios – timing of events, resource utilization, CONOPS, people affected, etc.
- Displays metrics that reflect technology and human-in-the-loop performance
- Allows alternative scenarios and architectures to be examined
- Can be used in analyst or role player modes



These capabilities allowed stakeholders to explore ConOps and evaluate and optimize the integrated defense systems for urban areas.

Knowledge elicitation, quantification and vetting was conducted throughout the BioDAC modeling and analysis process

Knowledge elicitation interviews

Conceptual model development

Meetings to validate conceptual models

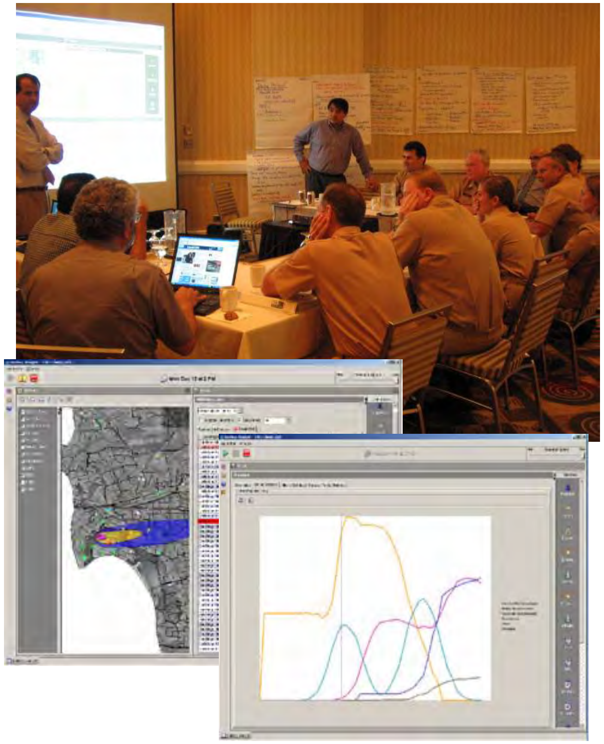
Conceptual model refinement

Simulation software development

Meetings and exercises to vet simulation

Simulation refinement

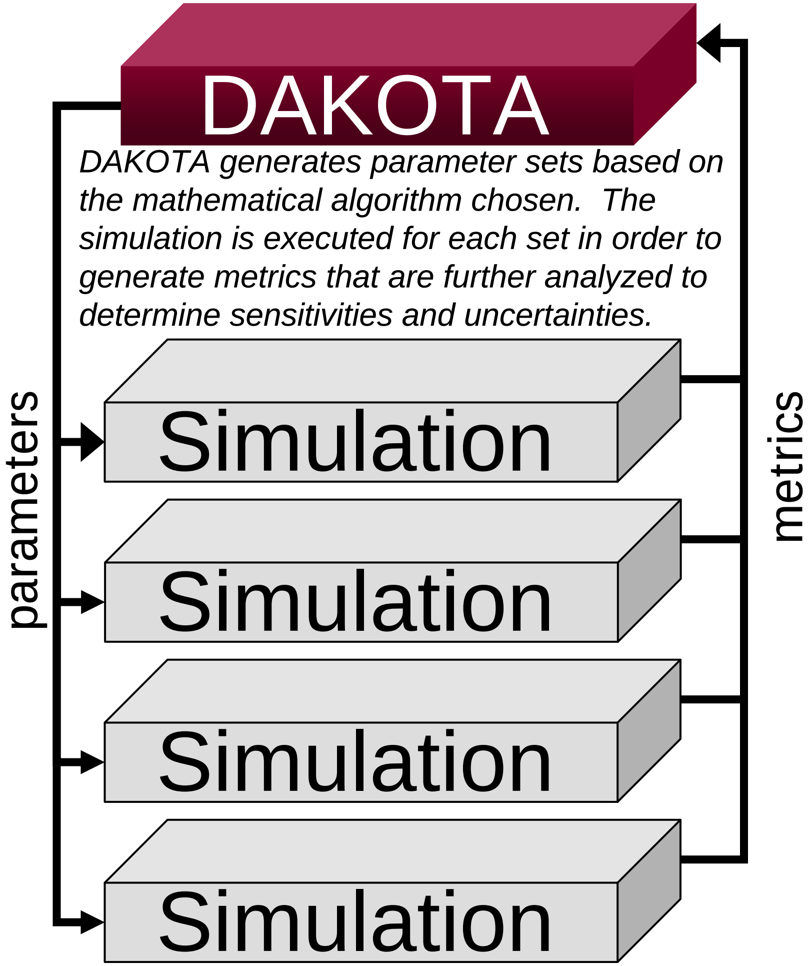
Use of simulation for exercises and analyses



These interactions and analyses provided insights and conclusions on operations and preparedness.

DAKOTA provides a common interface to an extensive set of algorithms for automated model exploration and analysis

- Getting the best coverage: sampling, design of computer experiments
  - Monte Carlo, Quasi-Monte Carlo, central composite, Box-Behnken, centroidal Voronoi tesselation
- Determining the most important parameters: sensitivity analysis
  - main effects, correlations, variance-based decomposition
- Analyzing the uncertainties: (epistemic) uncertainty quantification
  - second-order probability, Bayesian inference, Dempster-Shafer evidence theory
- Identifying the best/worst: optimization
  - mixed integer, multi-objective, multi-level, with or without uncertainty

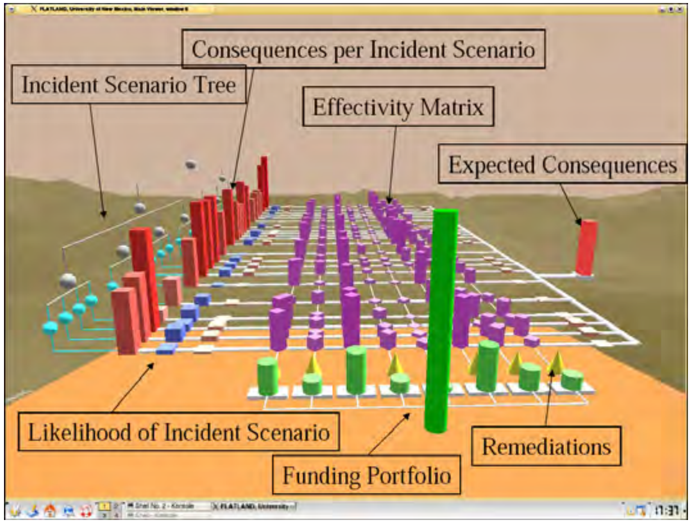


The Multivariate Investment Decision Support Tool provides an environment for studying technology investment strategies and optimization

MIDST: evaluates and optimizes R&D investment strategies to support program managers

- Collaboration
  - Collected scenario, investment options, technology performance, and consequence data
  - Integrate with to provide derived effectiveness metrics for new technologies based on IPAT analyses.

- Related presentations:
  - Data & Decision Support Tools
    - Roshan Rammohan, Wed, 4pm
    - Frank Gilfeather, Thurs, 8:45am
    - William Ogden, Thurs, 9:15am
    - Shan Xia, Thurs, 9:45am
  - Operational Effects
    - Nadipuram Prasad, Thurs, 3:30pm
    - Stephen Helmreich, Thurs, 4:30pm



The Multivariate Investment Decision Support Tool, which allows users to study tradeoffs between technology investment strategies, is being developed by the DTRA University Partnership Gold Team.

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Mitigating risks

The CBRN IPAT development strategy is multi-phase with initial emphasis on requirements elicitation.

- Phase 0: complete funding transfer
- Phase 1: User requirements analysis, knowledge elicitation, conceptual model formulation, bio attack scenario development, initial uncertainty characterization
- Phase 2: Simulation development and integration for bio attack scenarios. Initial uncertainty quantification and analyses.
- Phase 3: Investment tradeoff studies, vetting with decision makers and users.
- Phase 4: Extension to CRN scenarios, more sophisticated models, UQ, and analyses.

Summary

- The IPAT will support CBRN planning by allowing decision makers to evaluate investment options.
  - Informed investment decisions are critical to ensure robust risk mitigation, an accelerated response, and efficient recovery in case of a CBRN attack.
- This project will combine systems analysis, advanced modeling, computing and mathematical techniques, and state-of-the-art visualization technologies to create transparent, vetted methods and tools.
- The IPAT methods and tools will leverage existing capabilities and expertise developed through DTRA-, DHS- and DOE-sponsored programs.

Questions?

Joint Effects Model (JEM) Environmental Services Research and Development

George Bieberbach, Shane Swartz, Steve Sullivan,
Deirdre Garvey, Michael Raines, Howard Soh, Karen Arp,
Hank Fisher, Stephen Dowdy

National Center for Atmospheric Research
Research Applications Laboratory
Boulder, CO

NDIA CBIS
11 January 2007

Project Background

- **What: NCAR/RAL providing Environmental Research and Development (R&D) support to JEM program via DTRA/JSTO.**
- **Why: Transition R&D technologies and datasets, produced through DTRA/JSTO Weather Services R&D Project, into JEM system. Particular objectives include:**
  1. Assist with integration of DTRA Next Generation Meteorological Data Server (MDS) Application Programming Interface (API) into JEM.
     - Assist JSTO and JEM program manager with Testing & Evaluation / Verification & Validation of JEM with meteorological data from the MDS.
  2. Upgrade and and incorporate new environmental datasets.
     - Assist JSTO with quality assurance of all environmental data and tools in JEM.

Project Objective #1
DTRA Next Generation Meteorological Data Server (MDS) Integration

Legacy MDS Requirements

NCAR

- Provide simplified access to real time meteorological forecast model and observational datasets from a variety of sources for HPAC.
- Minimize bandwidth requirements for requested/retrieved datasets through spatial and temporal domain sub setting.
- Reformat data sources into HPAC specific weather formats.

All in all, these requirements have been met….BUT….

Legacy MDS Issues

- **PERFORMANCE**: User base has substantially grown.
  - **Struggling to cope with expanding user load.**
- **RELIABILITY**: Hardware and software configuration is antiquated.
  - **Based on 1990s technologies. Require extensive manpower to maintain.**
- **STOVE-PIPED**: HPAC centric system and interface.
  - **System not intended for general access by other software clients.**
- **SECURITY**: Originally used unsecured FTP for client server communication, with users given system accounts.
- **EXPANDABILITY**: System not easily expandable to support wider variety of data sources.
- **INDUSTRY STANDARDIZATION**: No industry standardization.

NexGen MDS Requirements

NCAR

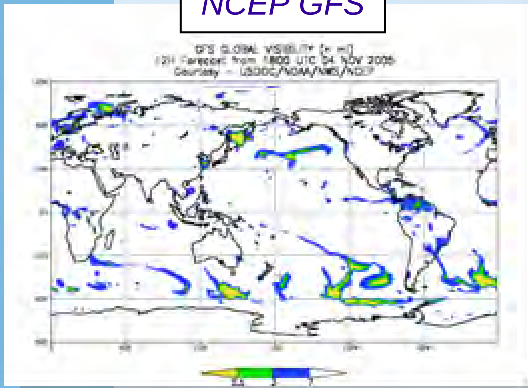
- Provide simplified and ***GENERALIZED*** access to real time, plus ***ARCHIVED***, meteorological forecast model and observational datasets from a variety of sources.
- Minimize bandwidth requirements for requested/retrieved datasets through spatial and temporal domain sub setting.
- Reformat data sources into HPAC specific weather formats and ***OTHER INDUSTRY STANDARD*** formats.

Plus…

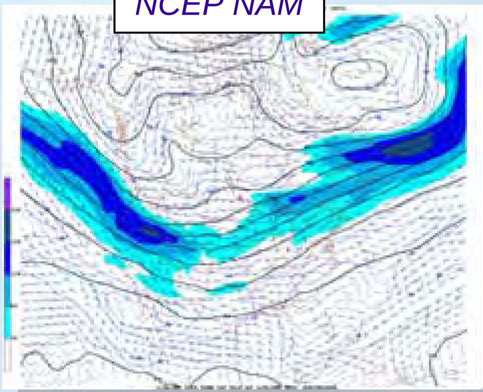
- **PERFORMANCE**: Improve performance to meet requirement of fulfilling 100 user requests in under 3 minutes.
- **RELIABILITY**: Increase reliability using high availability technologies.
- **SECURITY**: Improve user authentication and data transfer security using PKI and secure data transfer methodologies.
- **EXPANDABILITY**: Provide mechanism for easily expanding types of available data sources and formats.
- **INDUSTRY STANDARDIZATION**: Utilize web services standards for data access.

Available Model Data

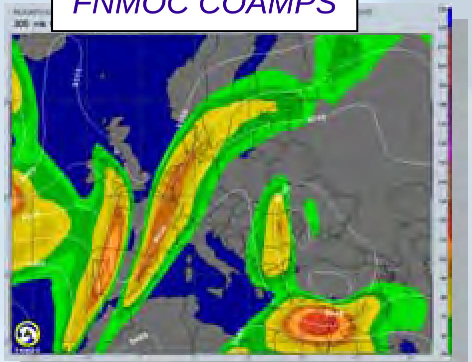
NCEP GFS



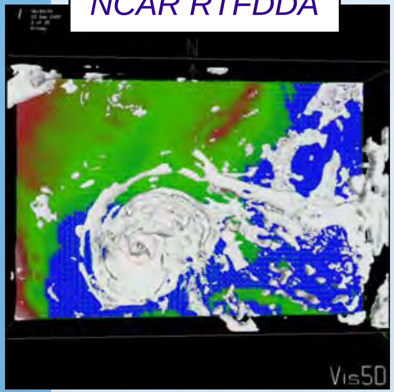
NCEP NAM



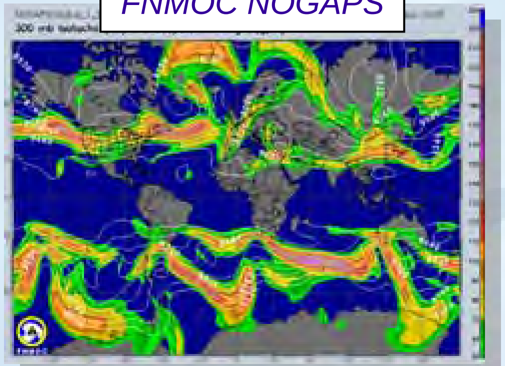
FNMOC COAMPS



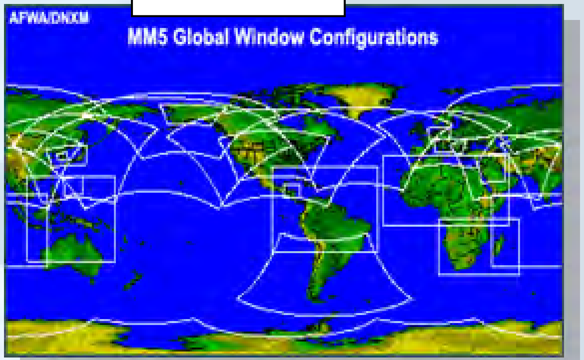
NCAR RTFDDA



FNMOC NOGAPS

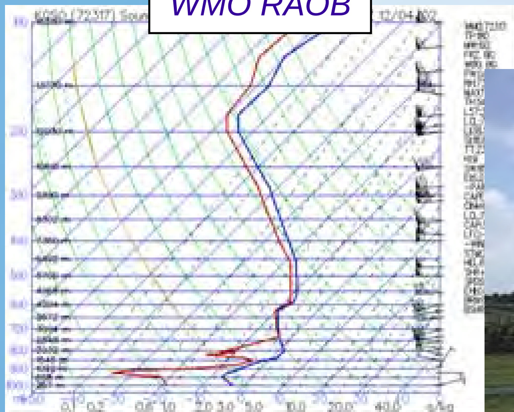


AFWA MM5



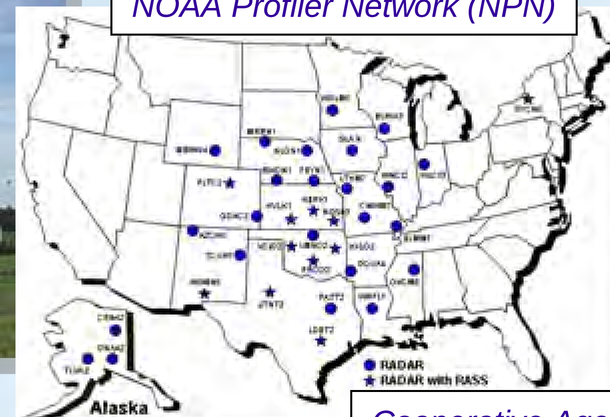
Available Observational Data

WMO RAOB

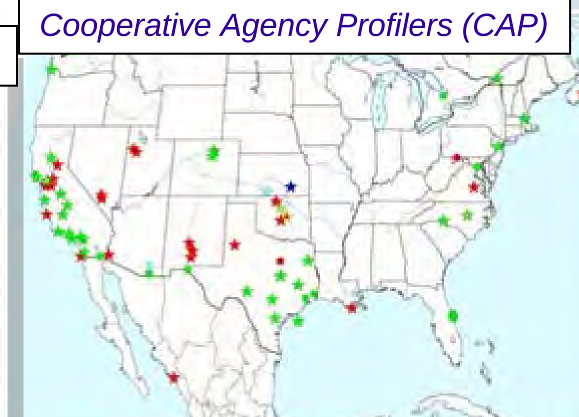


WMO METAR

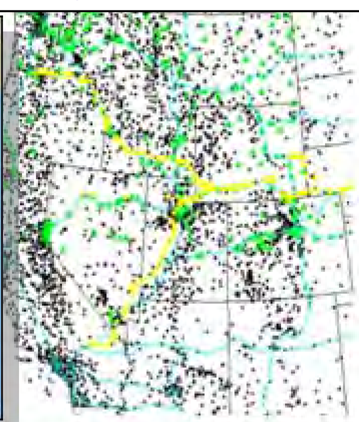
NOAA Profiler Network (NPN)



Cooperative Agency Profilers (CAP)



University of Utah Mesowest

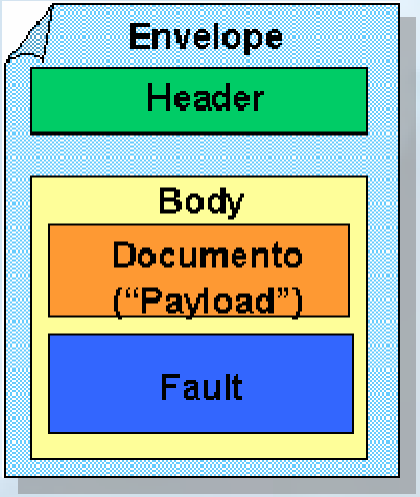


WeatherFlow

NWS Ships/Buoys

SOAP Access

- **Supports Web Services Simple Object Access Protocol (SOAP) via HTTP and HTTPS.**
- **Allows requests for a specific data source, output variable, vertical level, horizontal domain, and temporal domain.**
- **Includes metadata query capability to determine what data, variables, etc.. are currently available on system.**



Java API

NCAR

- **Java Application Programming Interface (API) serves as primary MDS interface.**
- **Authenticates users via Public Key Infrastructure (PKI) techniques.**
- **Supports the reprojection, interpolation, and reformatting of raw datasets.**
- **Currently provides datasets in NCAR Meteorological Data Volume (MDV) and HPAC specific formats.**

edu.ucar.rap.mds.client

Class WxDataRequest

```
java.lang.Object
  └ edu.ucar.rap.mds.client.WxDataRequest
```

All Implemented Interfaces:
java.lang.Cloneable

public class **WxDataRequest**
extends java.lang.Object
implements java.lang.Cloneable

Represents a single request for weather related data. Sample usage: see `TestDemo`

Field Summary	
java.lang.String[]	`fieldNames` Names of requested fields or null.
int	`fieldSet` field selection type: one of FIELDSET*.
double	`latMax` max latitude, decimal degrees (negative for S of the equator)
double	`latMin` min latitude, decimal degrees (negative for S of the equator)
double	`lonMax` max longitude, decimal deg (negative for W of Greenwich UK)
double	`lonMin` min longitude, decimal deg (negative for W of Greenwich UK)
java.lang.String	`modelName` Preferred model: One of "best", "NOGAPS", "GFS", "ETA", etc, or null.
java.lang.String	`outFile` Name of the output file.
int	`outFormat` Requested format of output file.
int	`outType`

MDS Components

NCAR

GATEWAY

- Efficiently distribute user requests to Server systems
- Serve as firewall between MDS public and private network

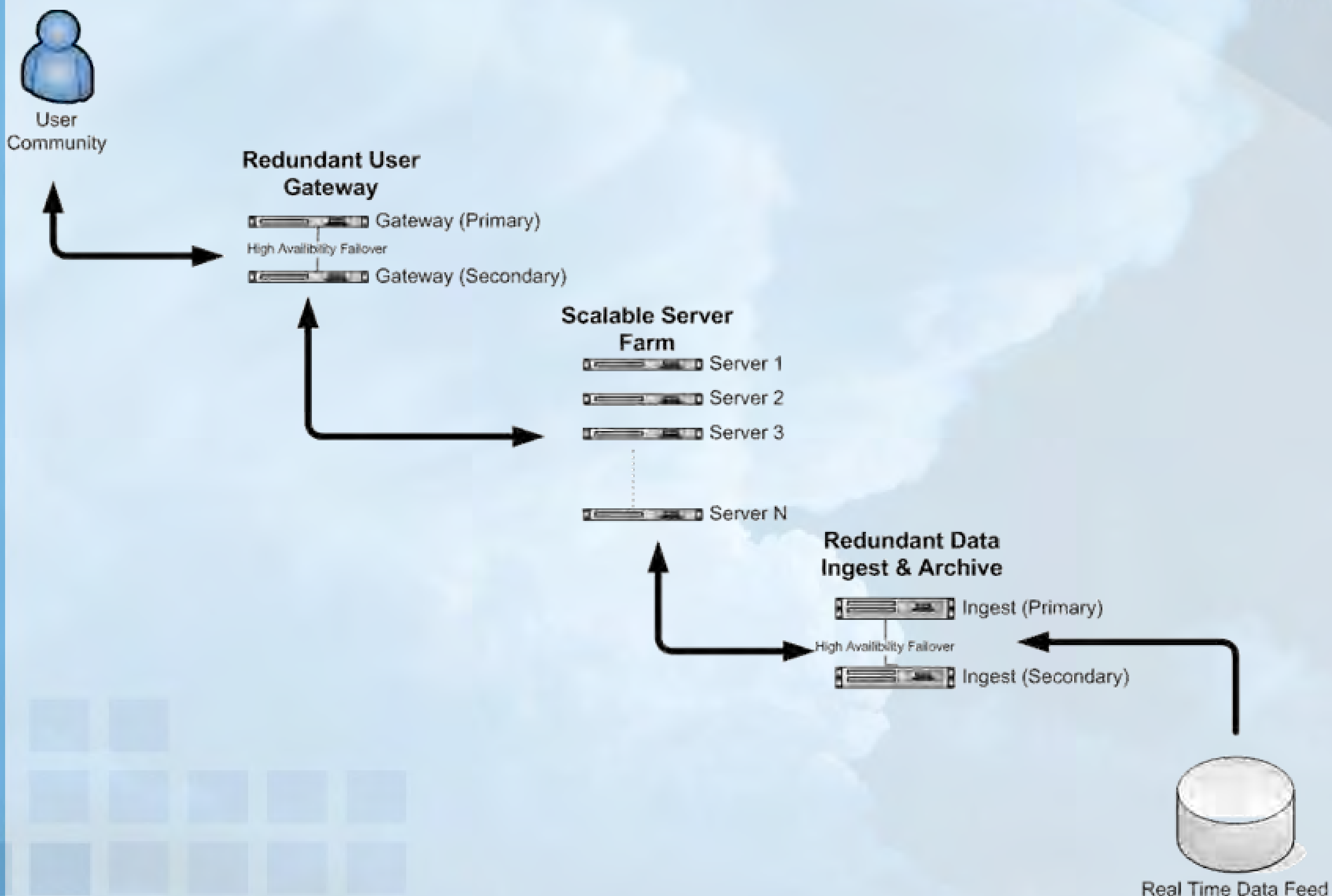
SERVER

- Authenticate user requests
- Process user requests
- Extract and deliver real time data sources upon request
- Forward requests for archived data sources to Ingest system

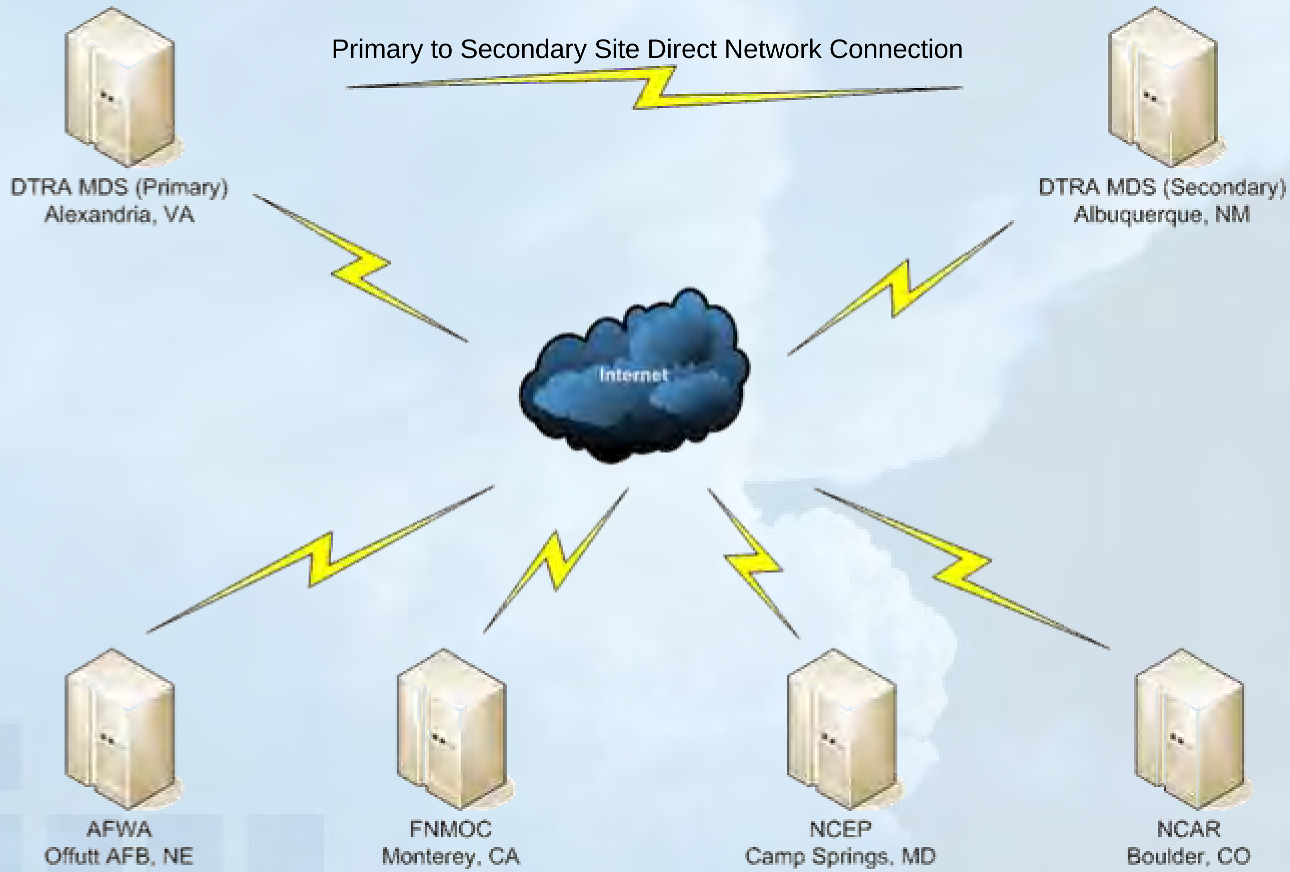
INGEST

- Ingest all incoming data sources
- Reformat raw model products into model data repository
- Reformat raw observational products into observational database
- Extract and deliver archived data sources upon request

System Architecture

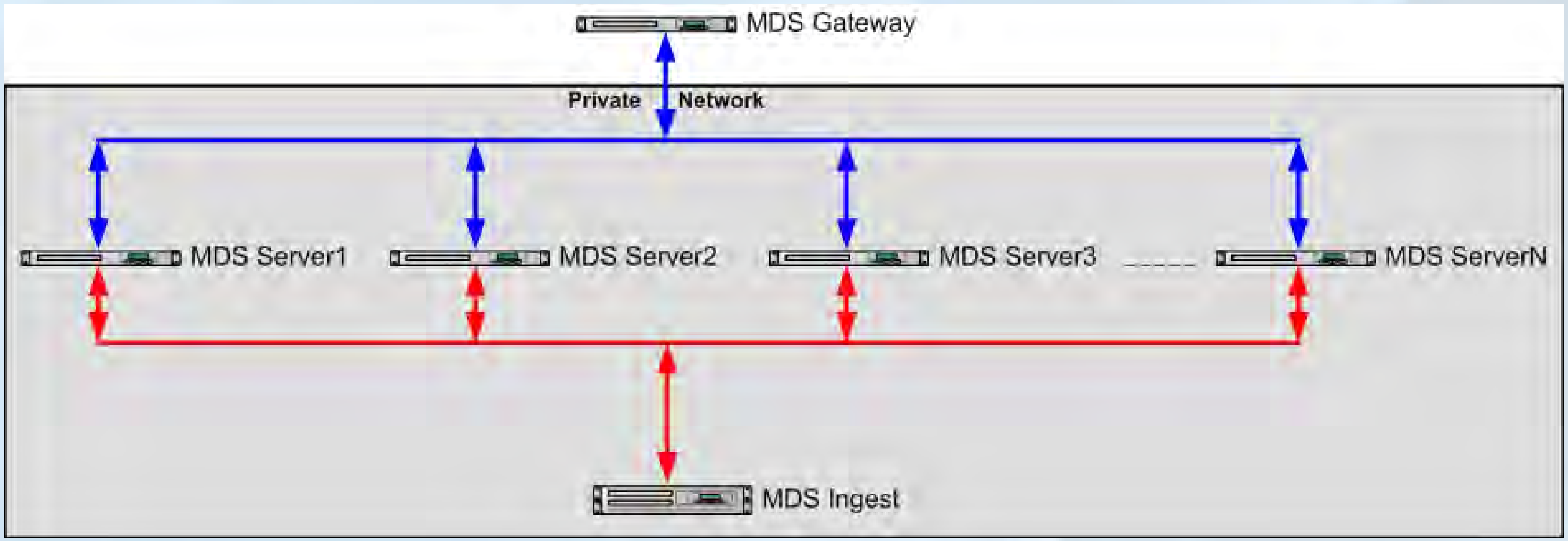


Redundant Server Locations



Server Farm

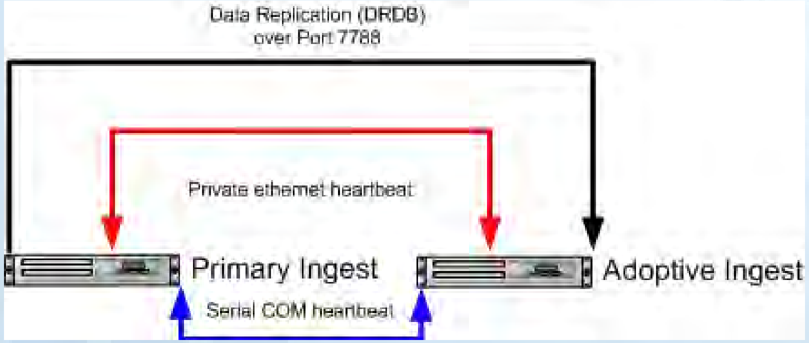
- Currently have 3 servers
- Can be expanded to N Servers



High Availability

Gateways Systems

Ingest Systems



- **Hot adoptive system**
- **Active / Passive Mode**
- **Real-time data replication on Ingest Systems**

Project Objective #1 Status and Plans

- MDS v1.0 delivered March 2006 and currently operational.
- MDS v1.1 on schedule to be delivered ~January - February 2007.
- MDS API successfully integrated into latest JEM baseline and undergoing testing by Northrop Grumman.
- MDS v1.2 development beginning.
  - New Data Sources:
    - AFWA and FNMOC KQ METARS
    - FSL MADIS
    - NCEP SREF, WRF-NMM, and GENS
  - Improved API
    - Support JMBL formatted requests
    - Utilize CBRN data model XML schemas
  - Expand Retrievable Data Formats
    - HPAC NexGen MEDOC
    - NATO METGM
    - WMO GRIB
    - Unidata netCDF
  - Enhanced Security
    - 2-way DoD PKI Authentication

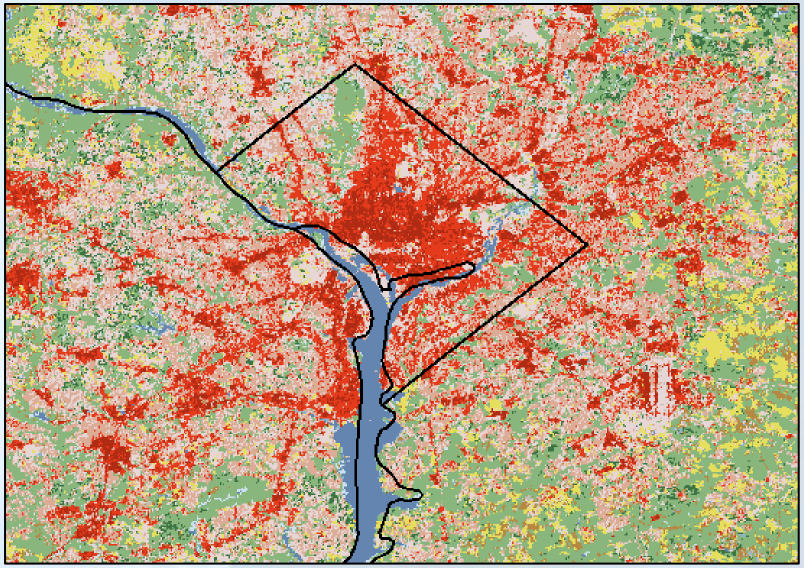
Project Objective #2
Environmental Database Enhancement and Integration

Land Cover Database

- Purpose:
  - **Used to determine agent surface absorption and secondary evaporation rates, plus surface layer turbulence profiles.**
- Details:
  - **1km horizontal grid spacing.**
  - **25 land use categories by season, which define:**
    - **Surface roughness**
    - **Surface albedo**
    - **Bowen ratio**
    - **Canopy Height**
    - **Canopy Flow Index**
  - **Based on 1993-1994 GOES AVHRR datasets.**

Land Cover Issues and Recommendations

- **Outdated and does not reflect the rapid urbanization of the last 10 years**
- **Provides one generic urban classification and does not discern the differences among different urban types (e.g., downtown, suburban residential areas, and commercial/industrial areas).**



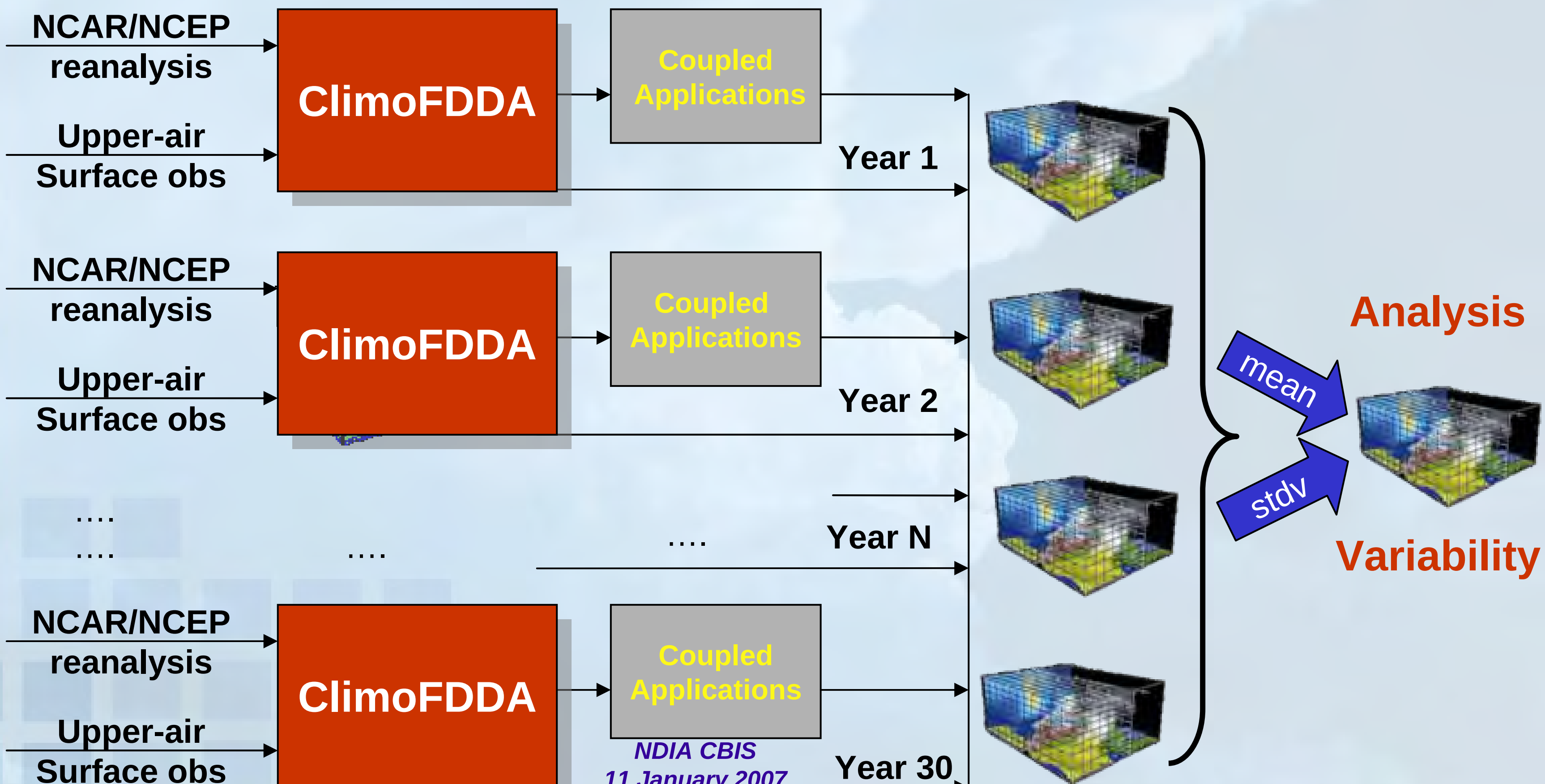
- **Recommended replacement:**
  - 2004-2005 MODIS database for natural surfaces merged with the 2002 30-m LANDSAT based USGS database for urban areas, which provides three separate classifications for urban land use.

Climatology Database

- **Purpose:**
  - Used to derive uncertainty associated with T&D calculations (e.g. Hazard areas).
- **Details:**
  - 2.0 Deg horizontal grid spacing
  - 28 vertical levels
  - Twelve 24 hour periods (6hour temporal resolution) containing:
    - Monthly means and stdevs of u and v wind components, plus u-v correlations
    - Monthly means of T, P, RH
    - Binned frequencies of occurrence of precipitation, wind speed, cloud cover.
  - Developed by AFCCC and based on 1996 NCEP/NCAR Global Reanalysis.

Recommended Climatology Replacement

- Updated database based on latest 50year NCAR/NCEP Global Reanalysis.
- Generate higher resolution databases, using NCAR Global Climatology Analysis Toolset (GCAT)



Project Objective #2 Status and Plans

- Database development scheduled to begin ~ March 2007.
- Anticipate first set of enhanced products to be delivered to JEM by early 2008.

Summary

- Supporting development and integration of DTRA NexGen MDS capabilities into JEM system.
  - First version of MDS API delivered and successfully integrated into JEM.
  - Development of next version of API underway in concert with ongoing MDS enhancements.

- Enhancing and upgrading JEM environmental databases
  - Focusing on enhancement of land cover and climatological databases
  - Development to begin March 2007.
  - First set of enhancements to be delivered early 2008.

Contact Information

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Fast Pressure Calculations on Buildings to Improve Outdoor-to-Indoor Transport & Dispersion

Michael Brown[1], Akshay Gowardhan[1,2], Matt Nelson[1], Mike Williams[1], and Eric Pardyjak[2]

[1]Los Alamos National Laboratory
[2]University of Utah

2007 CBIS Conference
Austin, TX

Los Alamos NATIONAL LABORATORY

Presentation Outline

• **Why Pressure Important for T&D Applications**

- Pressure Distribution on Buildings Influences Air Exchange Rate

• **Modeling Tools**

- QUIC-URB Wind Model
- QUIC Pressure Solver

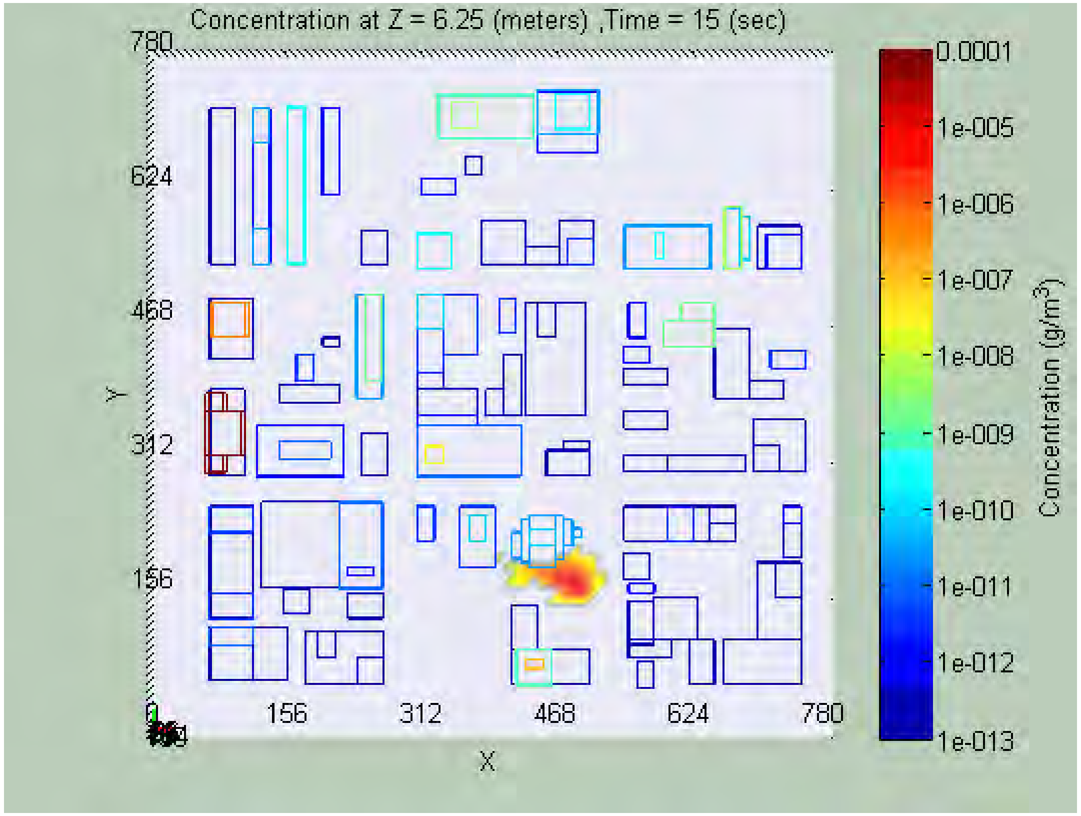
• **Model Evaluation**

• **How the fast wind & pressure models could be used to improve Indoor T&D calculations**

Motivation

- **Outdoor Releases Infiltrate into Buildings**

5 minute duration outdoor release

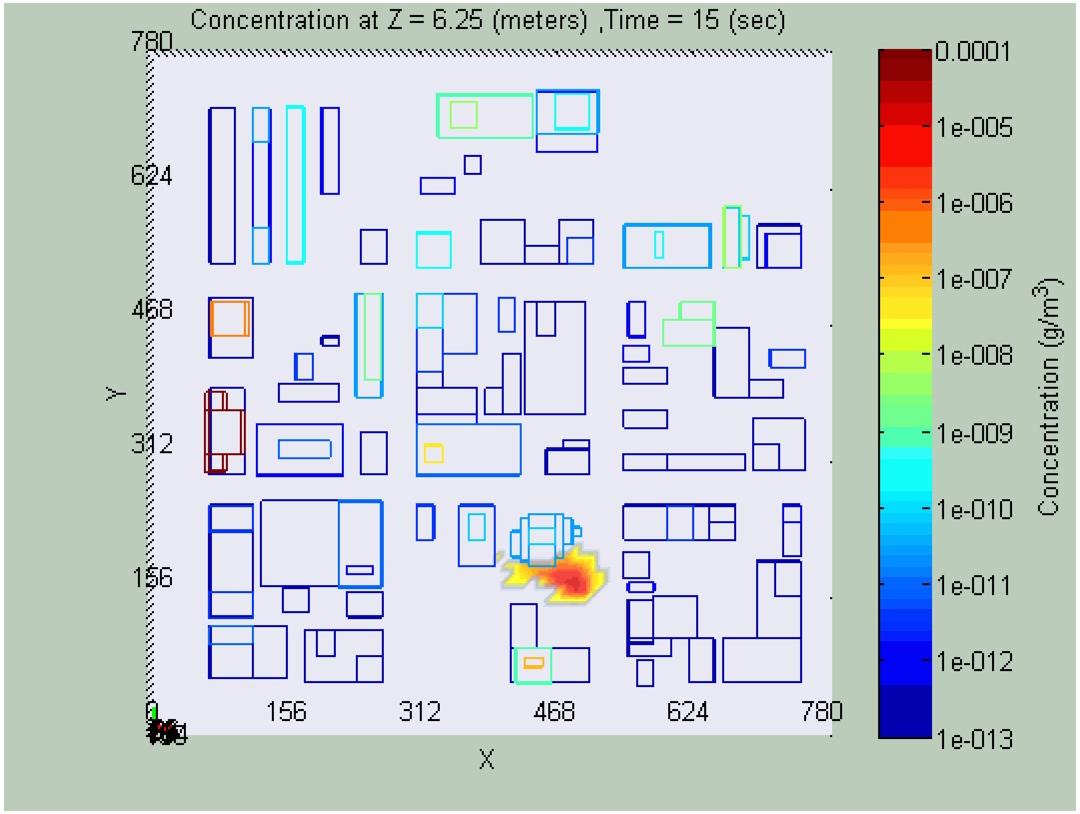


½ hour QUIC Salt Lake City simulation

Motivation

- **Outdoor Releases Infiltrate into Buildings**

5 minute duration outdoor release

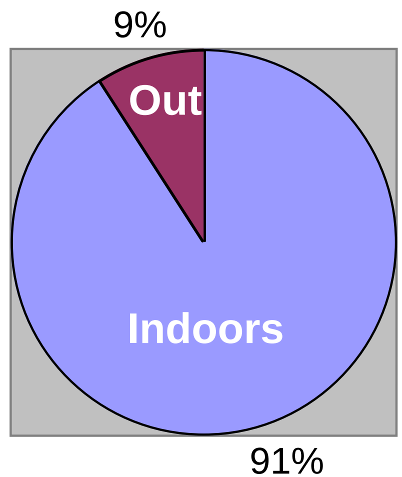


½ hour QUIC Salt Lake City simulation

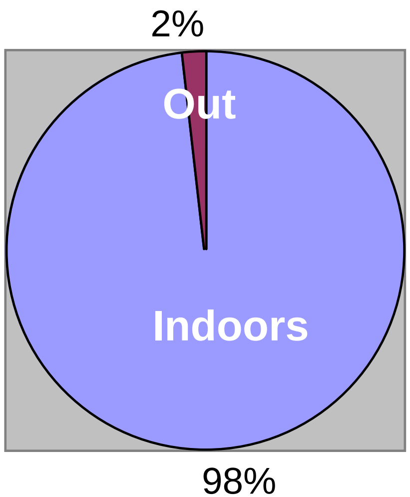
Motivation

- Outdoor Releases Infiltrate into Buildings
- **Population mostly resides Indoors**

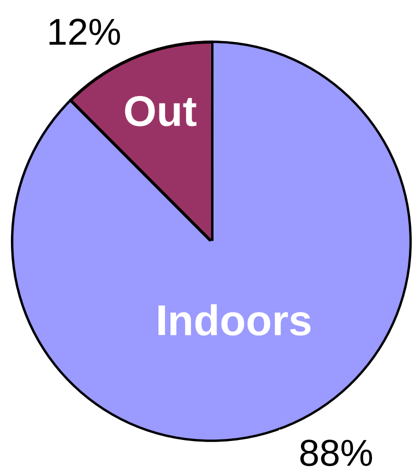
Daytime Residential



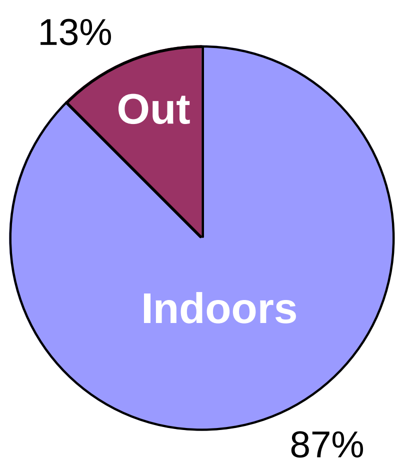
Nighttime Residential



Daytime Workers



Nighttime Workers



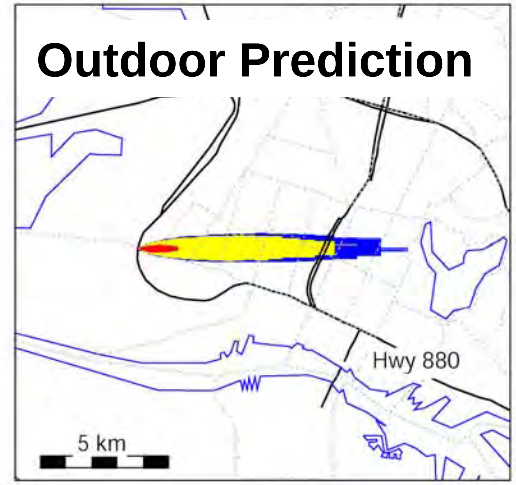
LANL USA Day-Night Indoor-Outdoor Pop DB

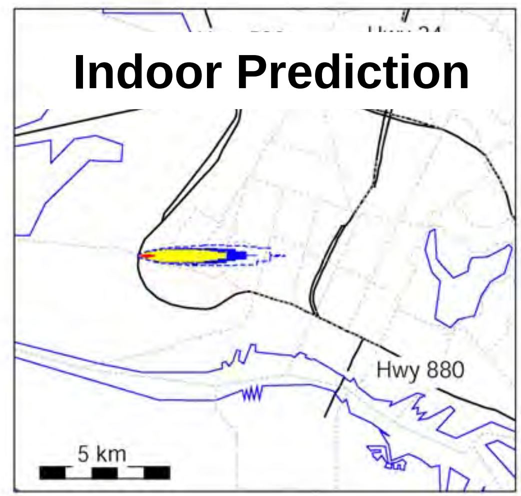
McPherson, T., A. Ivey, and M. Brown, 2004: Determination of the spatial and temporal distribution of population for air toxics exposure assessments, AMS 5th Symp on Urban Environment, Vancouver, BC.

Motivation

- Outdoor Releases Infiltrate into Buildings
- Population mostly resides Indoors
- **Exposure estimates can be much smaller if building “protection” considered**

Gadgil, 2005
GMU T&D
Workshop



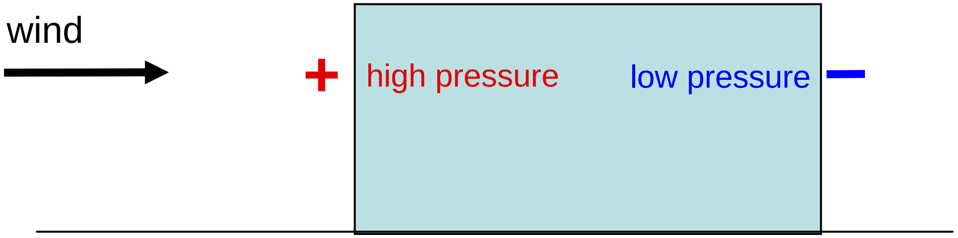


Transient Effects	Irreversible Effects	Life Theatening

Acute **E**xposure **G**uideline **L**evels

Motivation

- Outdoor Releases Infiltrate into Buildings
- Population mostly resides Indoors
- Exposure estimates sensitive to building "protection"
- **Air exchange for naturally-ventilated buildings is proportional to wind-induced pressure on building walls**



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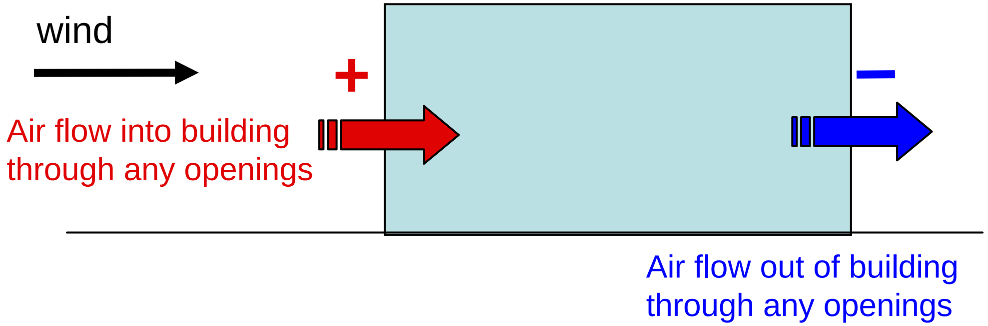

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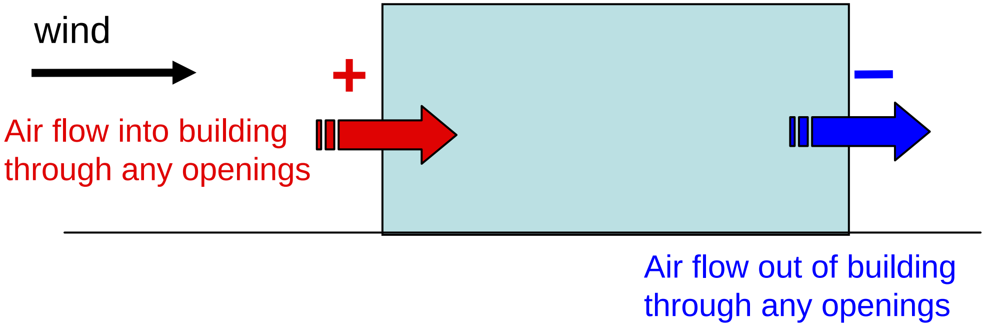

Chan et al. (2005) – Most residential buildings in US do not have mechanical ventilation systems

Motivation

- **Outdoor Releases Infiltrate into Buildings**
- **Population mostly resides Indoors**
- **Air exchange for naturally-ventilated buildings is proportional to wind-induced pressure on building walls**

Pressures on surface used as boundary conditions in CFD and multi-zone models, e.g., **COMIS**

Orifice equation

$$Q_f = ELA_{bldg} * (2 * \Delta P_{bldg} / \rho)^{1/2}$$

Q_f = volumetric airflow rate
ELA = effective leakage area of bldg

In practice

$$Q_f = k * \Delta P^{n} \qquad 0.6 < n < 0.7$$

Motivation

- Outdoor Releases Infiltrate into Buildings
- Population mostly resides Indoors
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- **Air exchange for naturally-ventilated buildings is proportional to wind-induced pressure on building walls**

The Urban Dispersion Model (UDM)

The Air Exchange Rate (AER) is due to a Buoyancy ("stack") Pressure and a Wind-Induced Pressure.

Ignoring the stack pressure effect (e.g., $T_{indoor}=T_{outdoor}$)

$$\boxed{AER_{bldg} = (AER_{ref} / \Delta P_{ref}^{2/3})*\Delta P_{bldg}^{2/3}}$$

Indoor Concentration

$$\chi_i(t) = e^{\frac{-t}{\tau}}\left[\chi_{out}(t_s) + \int_{t_s}^{t} \frac{\chi_{out}(t')}{\tau} e^{\frac{-t}{\tau}} dt'\right]$$

where

$$\tau = \frac{3600}{AER}$$

Wind & Pressure Solvers

Idea:

Use Fast Solvers To Compute **Pressure Field** on Buildings and Provide as Input to **Indoor Models**

3D Buildings → Inflow Wind Profile

↓

QUIC-URB

↓

3D Wind Field

↓

QUIC-Pressure Solver

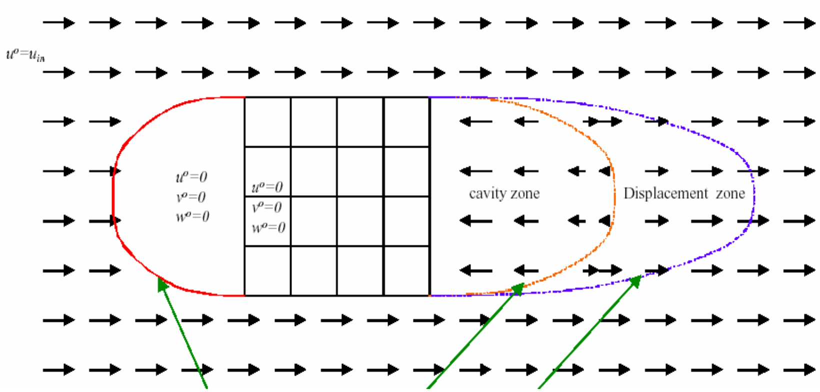
↓

3D Pressure Field

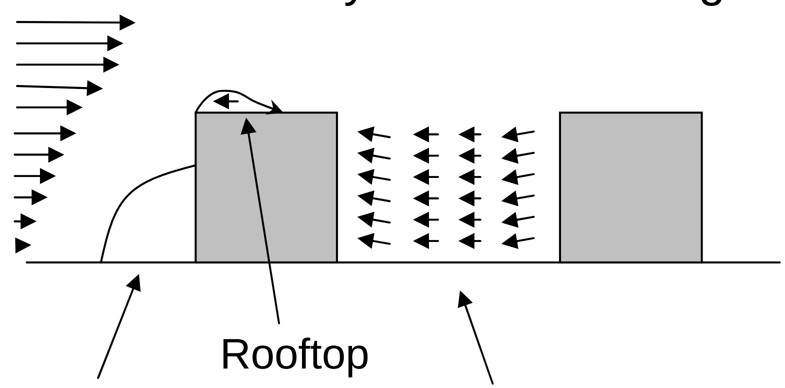
QUIC-URB Wind Solver

- Based on dissertation of Röckle (1990)
- 3D winds obtained from diagnostic/empirical method
- Initial winds based on building spacing and geometry
- Then mass conservation imposed (Sherman,1978)

Isolated Buildings



Densely Packed Buildings



QUIC-URB Wind Solver

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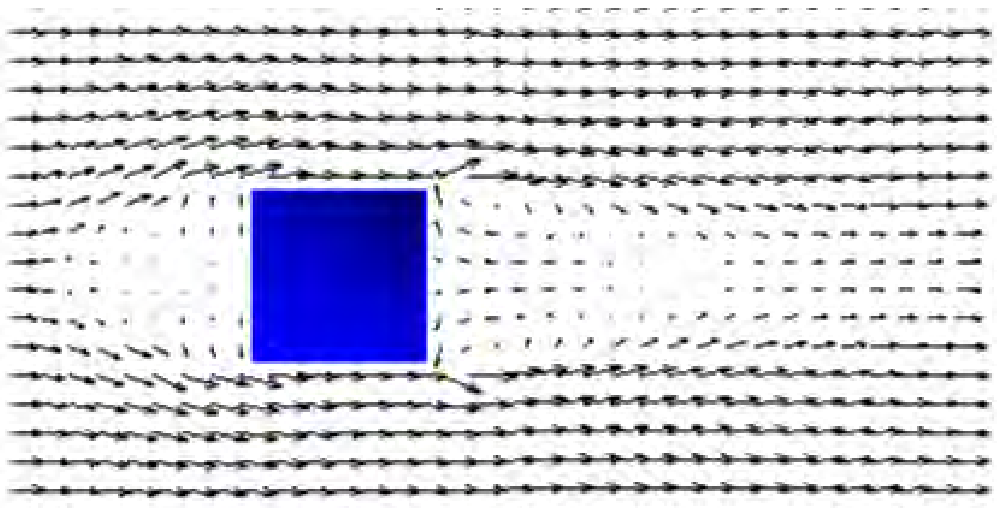
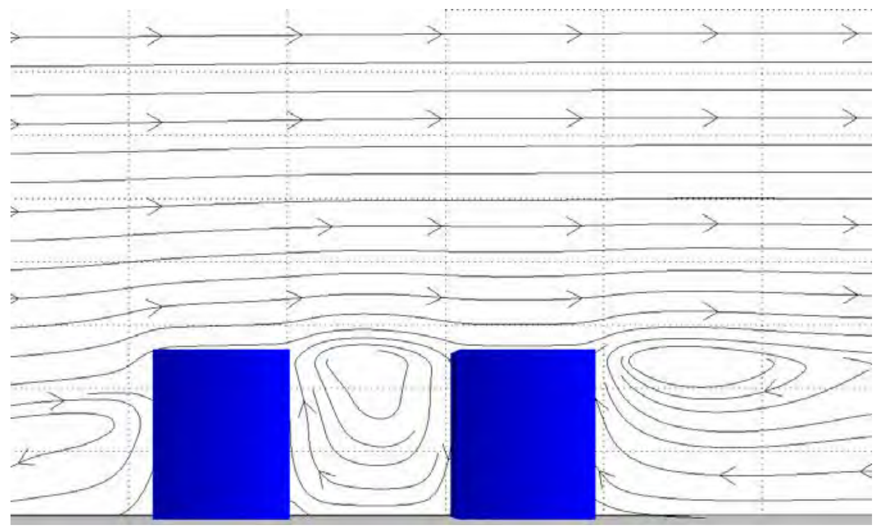


Densely Packed Buildings



QUIC Pressure Solver (Gowardhan et al., 2006)

Momentum Equation:

$$\cancelto{0}{\frac{\partial \overline{U_i}}{\partial t}} = -\underbrace{\frac{\partial(\overline{U_i}\,\overline{U_j})}{\partial x_j}}_{\mathrm{I}} - \frac{1}{\rho}\frac{\partial \overline{P}}{\partial x_i} - \underbrace{\frac{\partial(\overline{u'_i u'_j})}{\partial x_j}}_{\mathrm{II}} + \nu \underbrace{\frac{\partial^2 \overline{U_i}}{\partial x_j \partial x_j}}_{\mathrm{III}} \qquad (1)$$

where,

I - Advective terms

II -Reynolds stress terms

III -Diffusive terms

Assuming ***steady state*** *and taking* ***divergence*** *of Eqn. 1*

QUIC Pressure Solver

$$\frac{\partial}{\partial x_i}\left(\frac{\partial \overline{P}}{\partial x_i}\right) = \rho \frac{\partial}{\partial x_i}\left(\nu \frac{\partial^2 \overline{U_i}}{\partial x_j \partial x_j} - \frac{\partial(\overline{U_i}\,\overline{U_j})}{\partial x_j} - \cancelto{0}{\frac{\partial(\overline{u'_i u'_j})}{\partial x_j}} \right) \qquad (2)$$

- *The pressure Poisson equation is solved by iterative method with* $\partial p / \partial n = 0$

- *Reynolds Stresses are neglected due to lack of information*

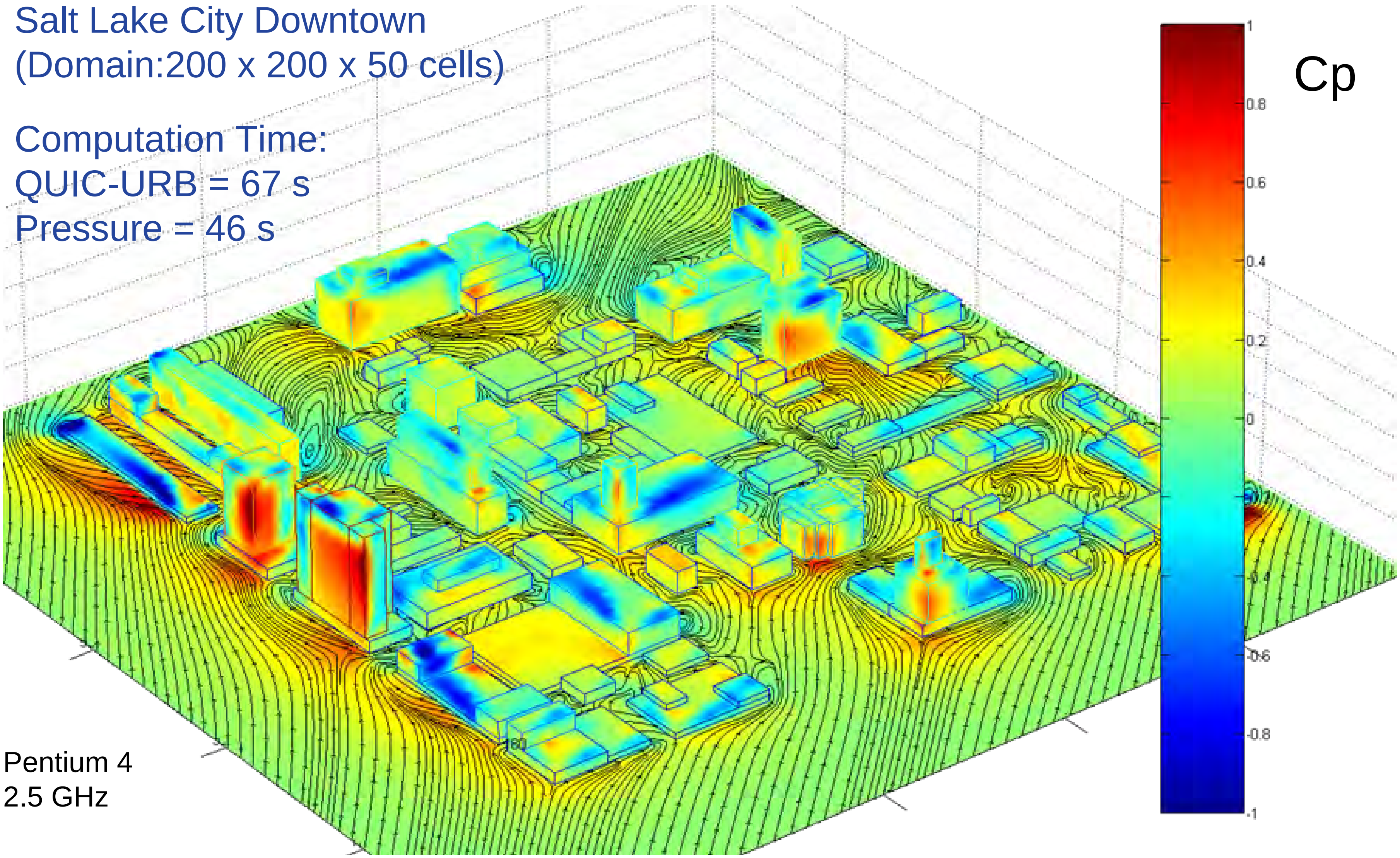
- *Coefficient of Pressure is calculated using the following formula:*

$$C_p = \frac{\overline{P} - \overline{P_o}}{\left(\frac{1}{2}\rho V_o^2\right)}$$

QUIC Wind & Pressure Solvers

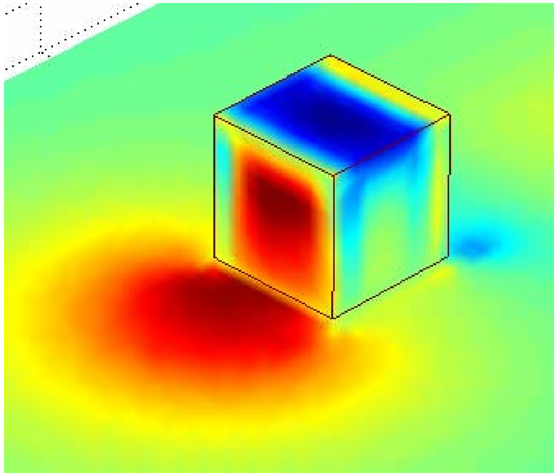
Salt Lake City Downtown
(Domain:200 x 200 x 50 cells)

Computation Time:
QUIC-URB = 67 s
Pressure = 46 s

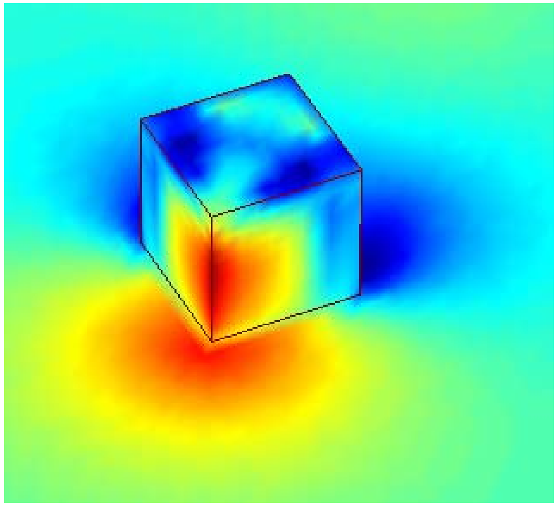


Pentium 4
2.5 GHz

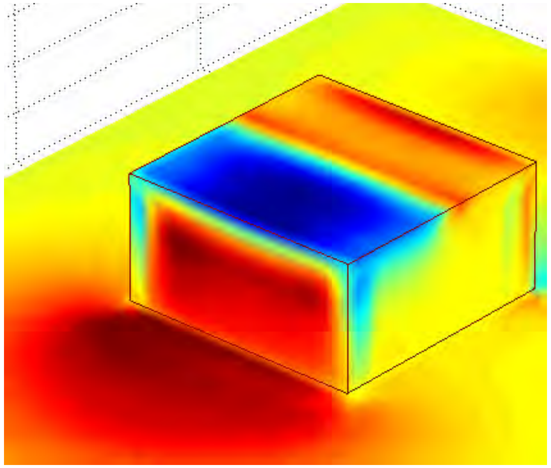
Model Evaluation Cases



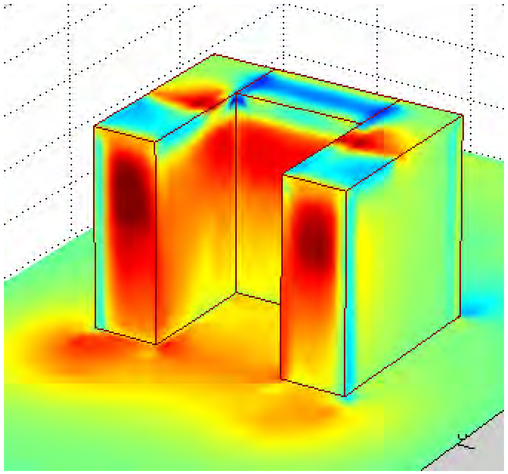
Cube (90 deg)



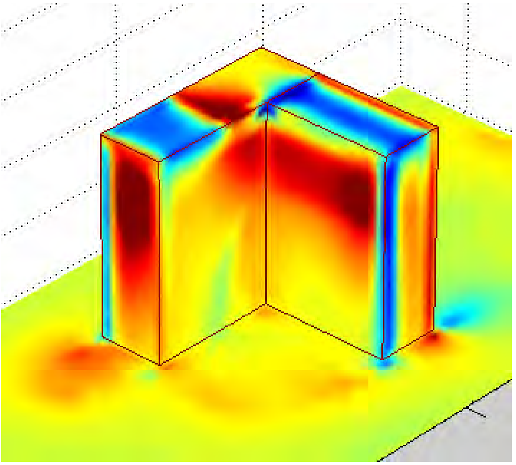
Cube (45 deg)



Squat

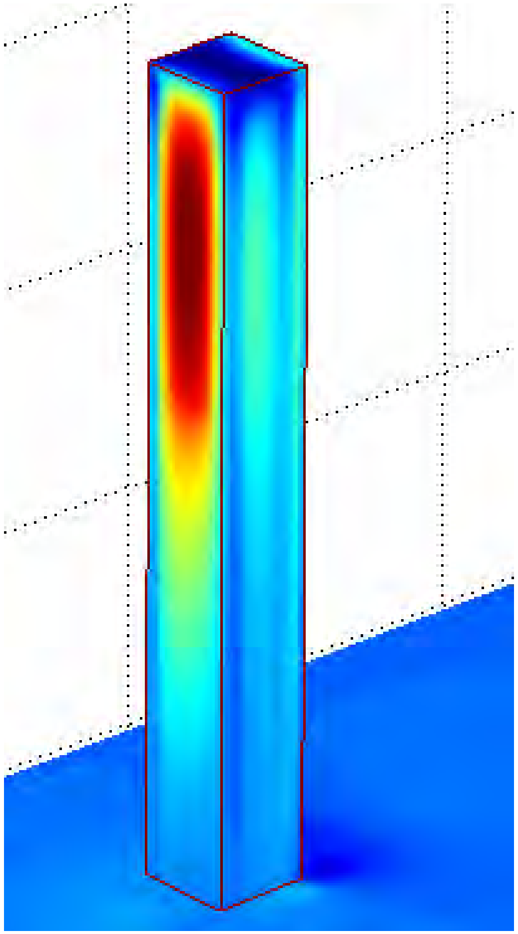


U-shaped

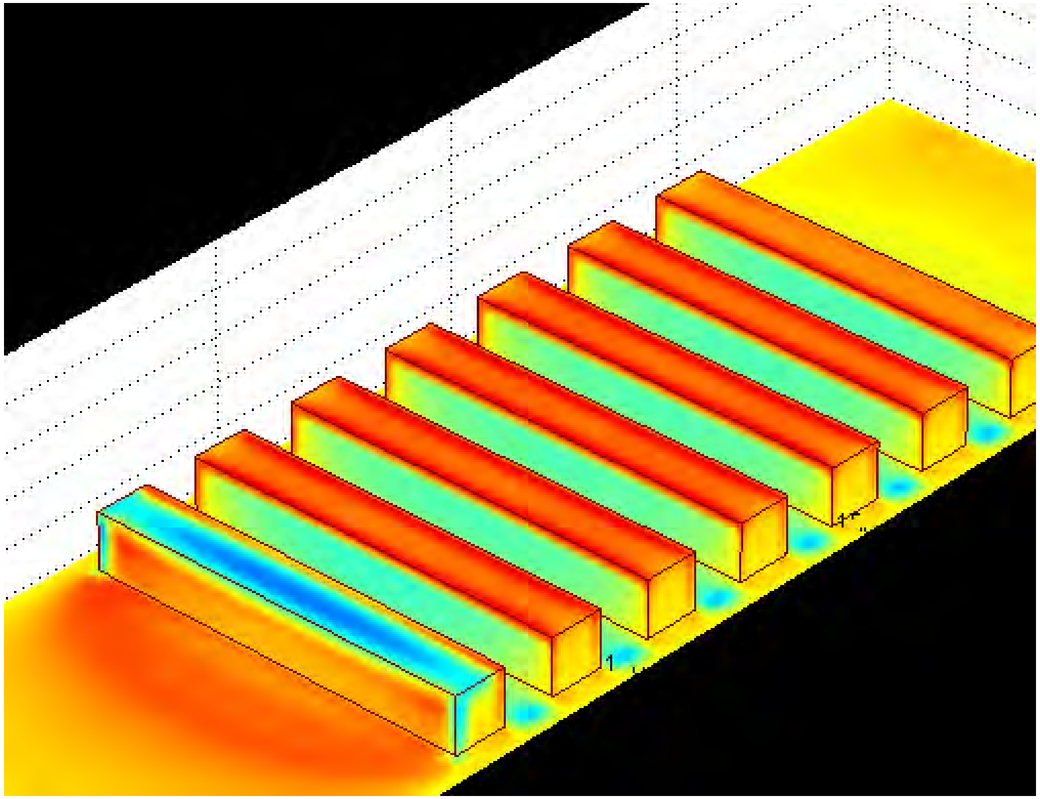


L-shaped

Model Evaluation Cases

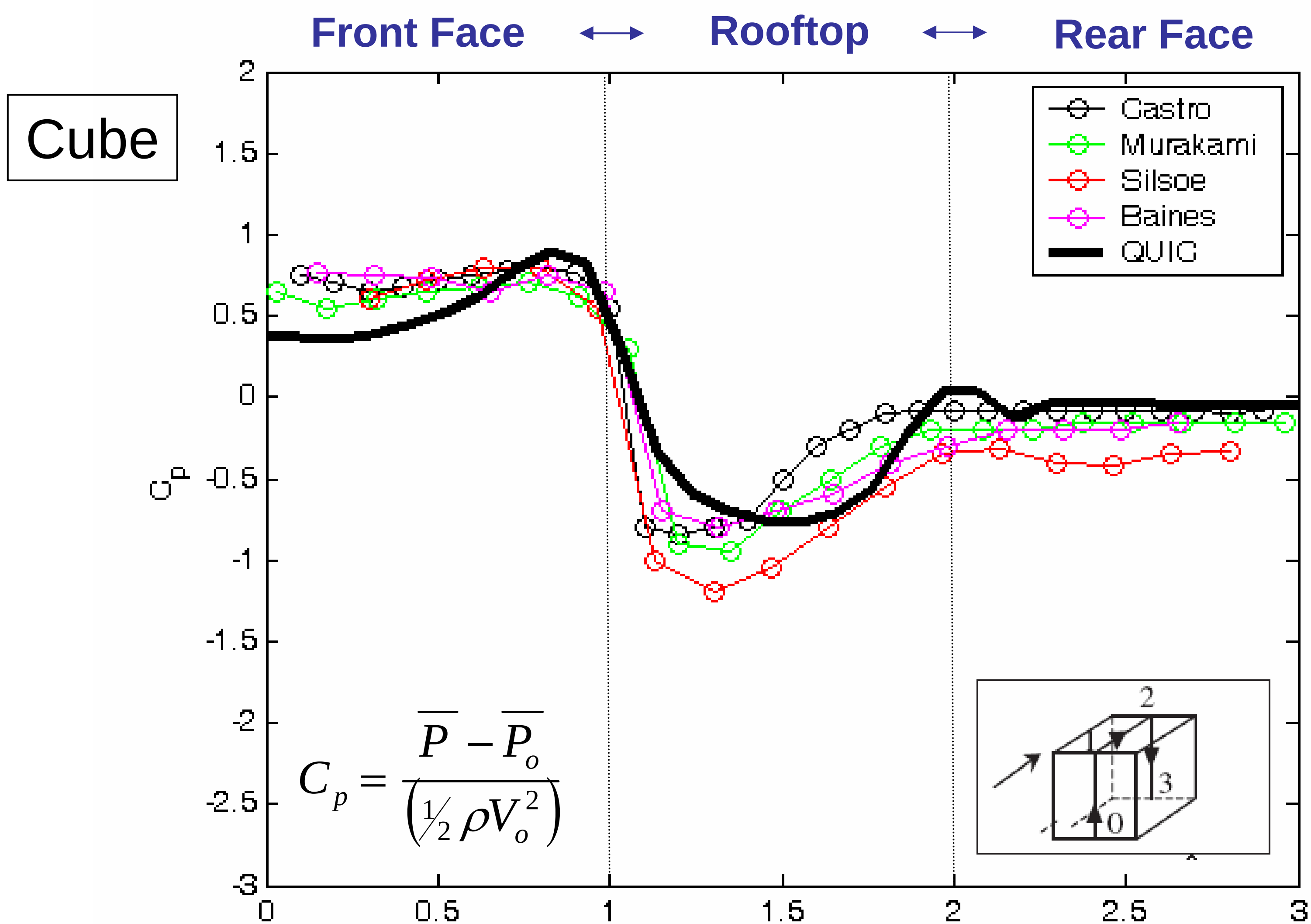


High-Rise



7x1 Wide Building Array

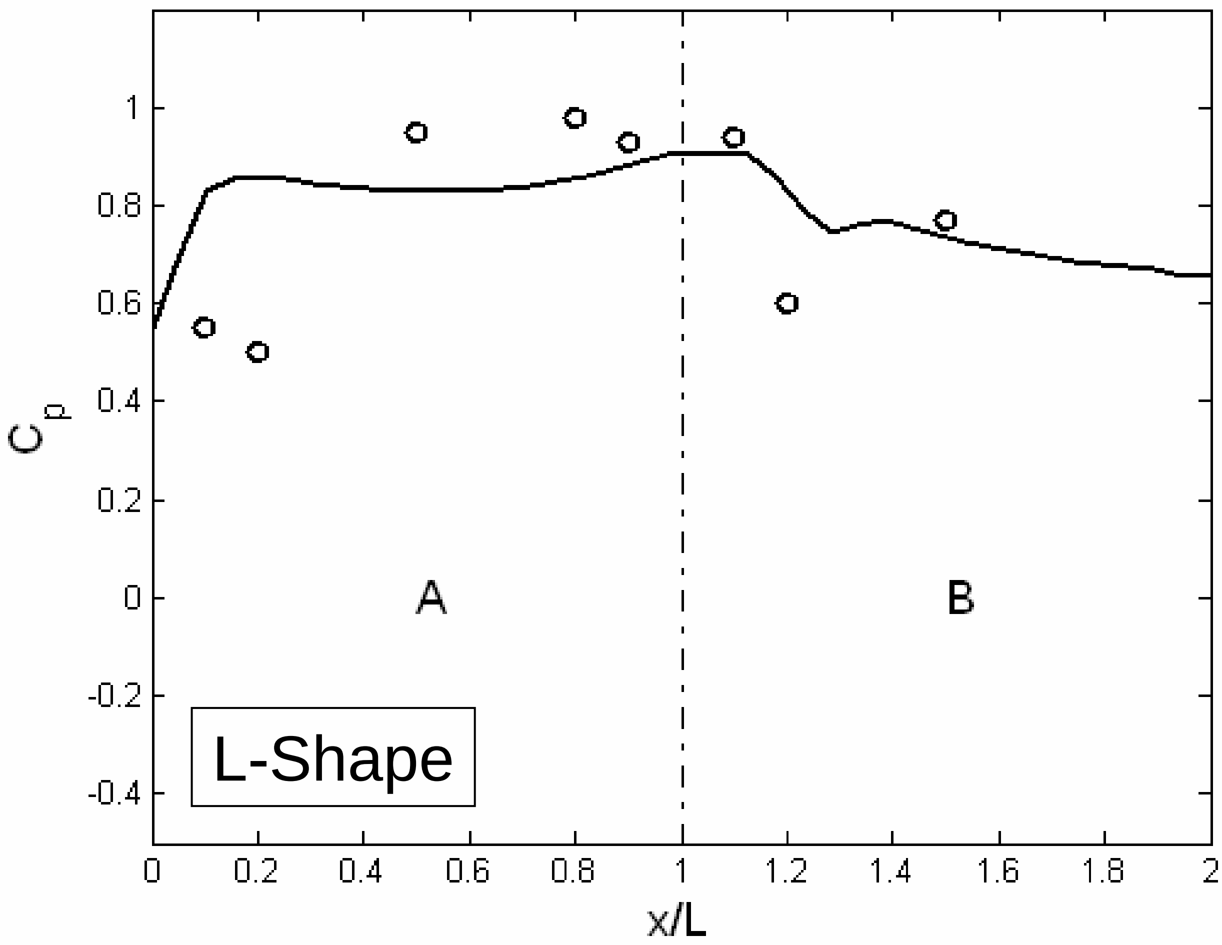
QUIC vs. Experimental Data: Cube (90 deg.)

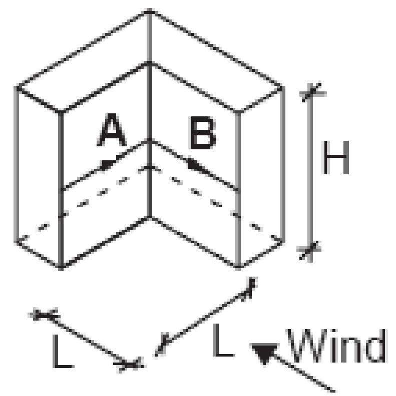


Adapted from Richards & Hoxey (2006)

QUIC vs. Experimental Data: L-Shaped Building

Front Face A ⟷ Side Face B

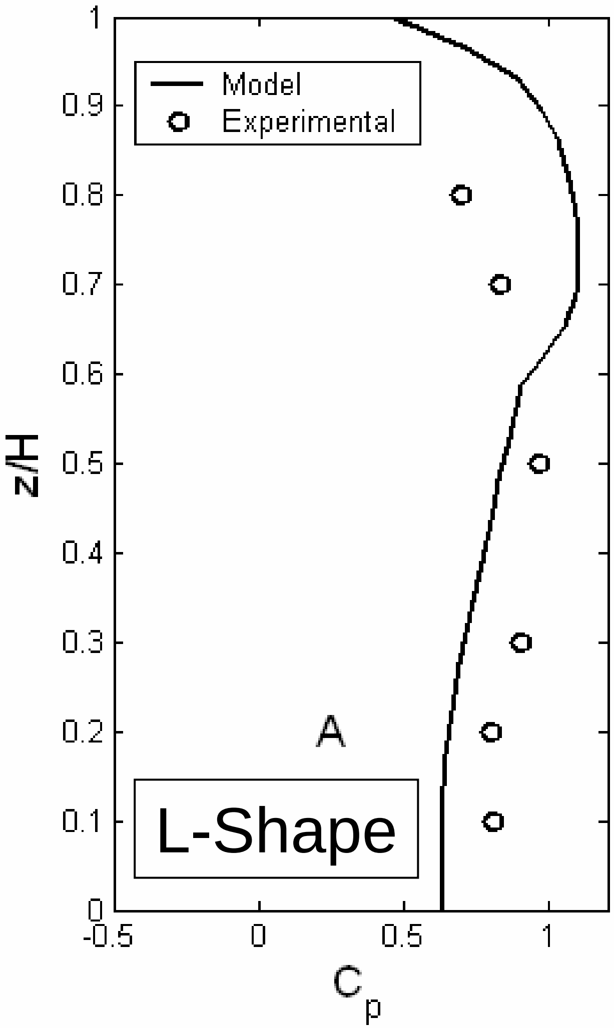




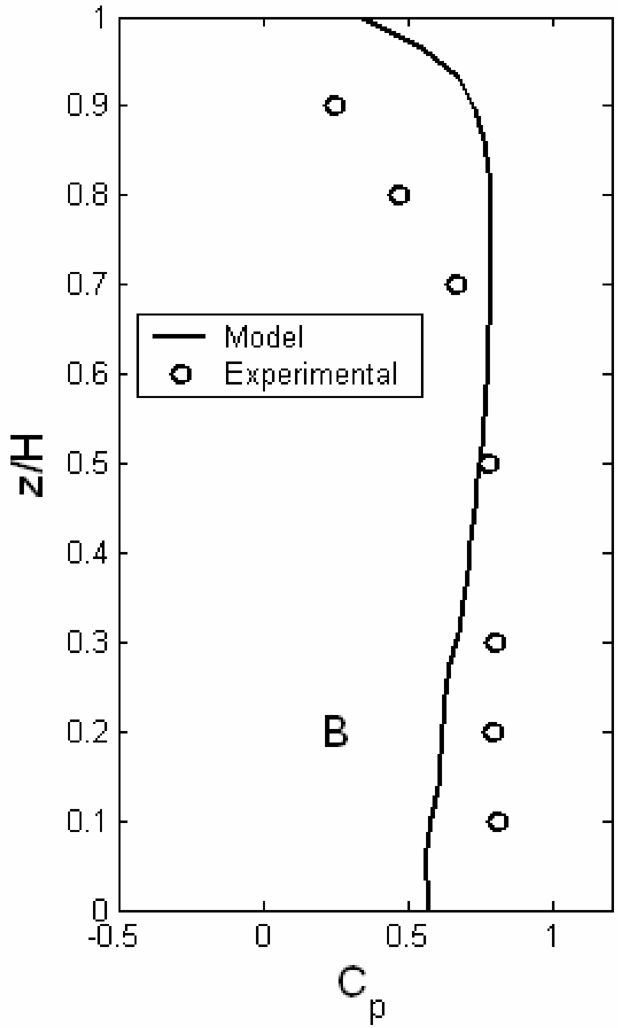
Adapted from Gomes et al (2005)

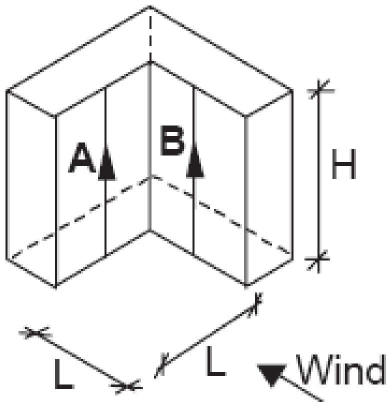
QUIC vs. Experimental Data: L-Shaped Building

Front Face A



Side Face B

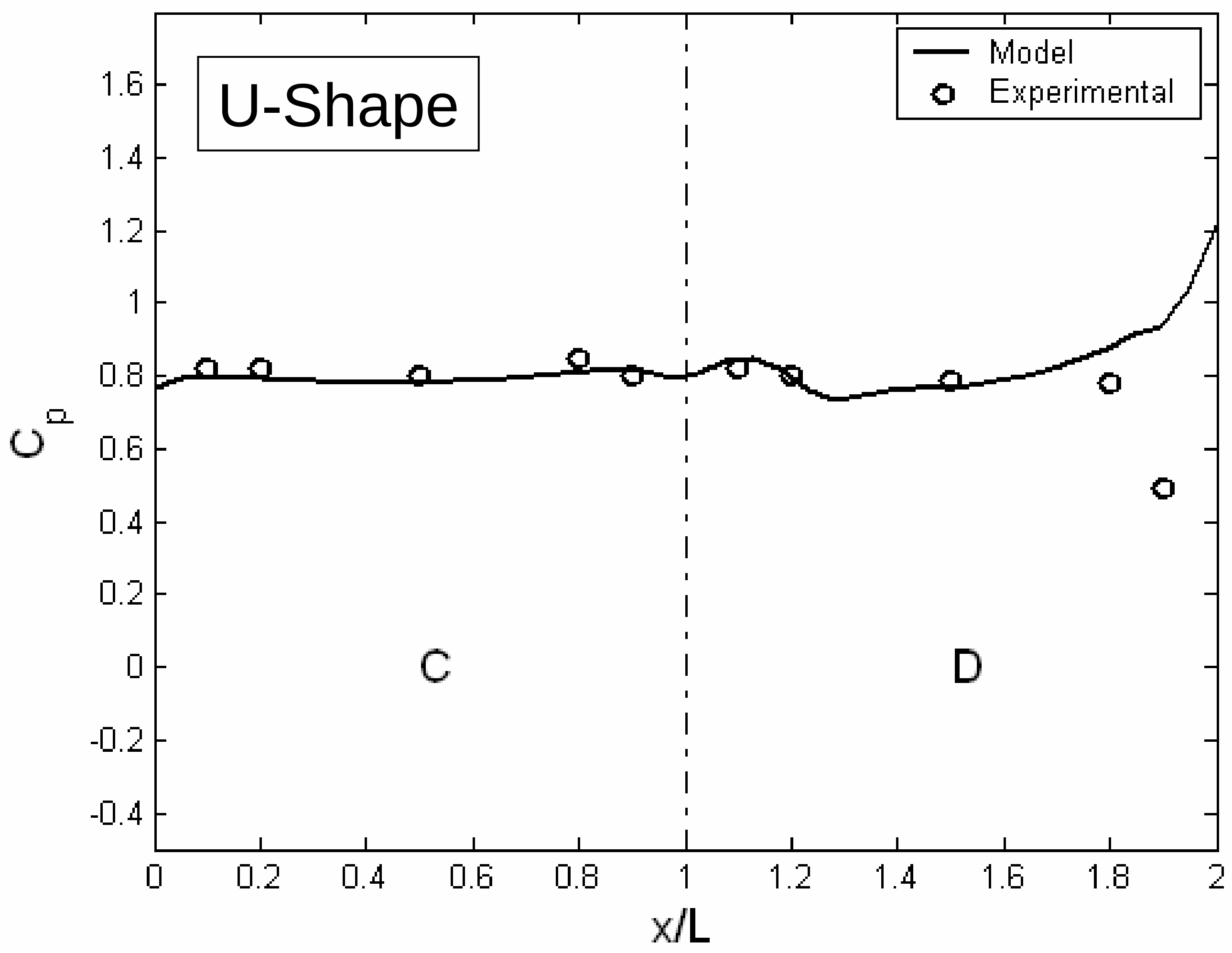


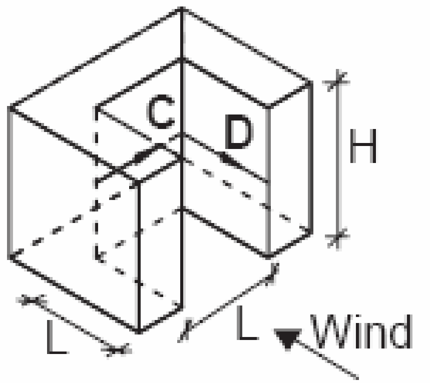


Adapted from Gomes et al (2005)

QUIC vs. Experimental Data: U-Shaped Building

Front Face C ⟷ Side Face D

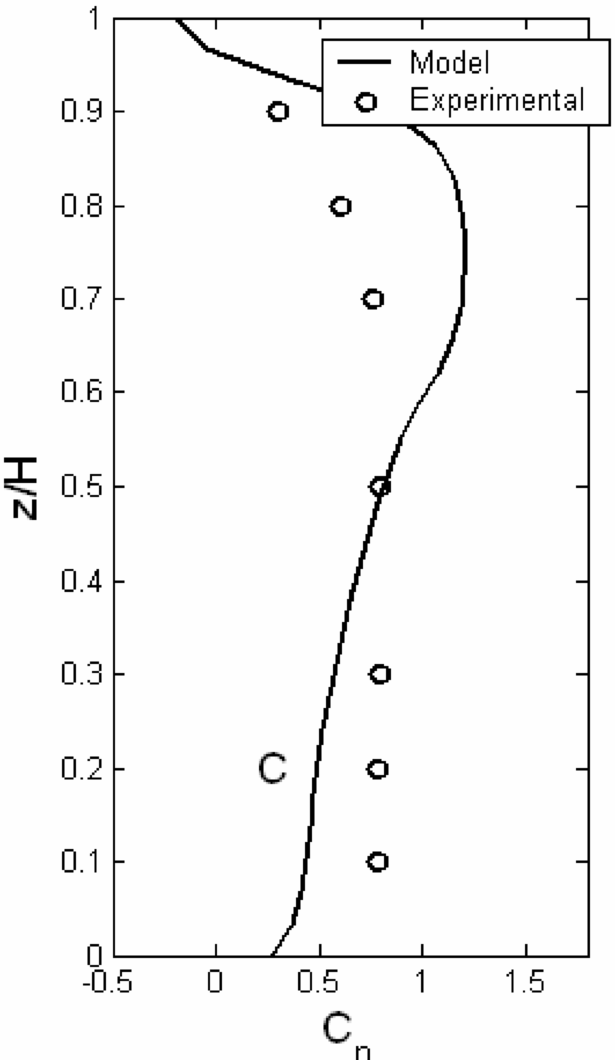




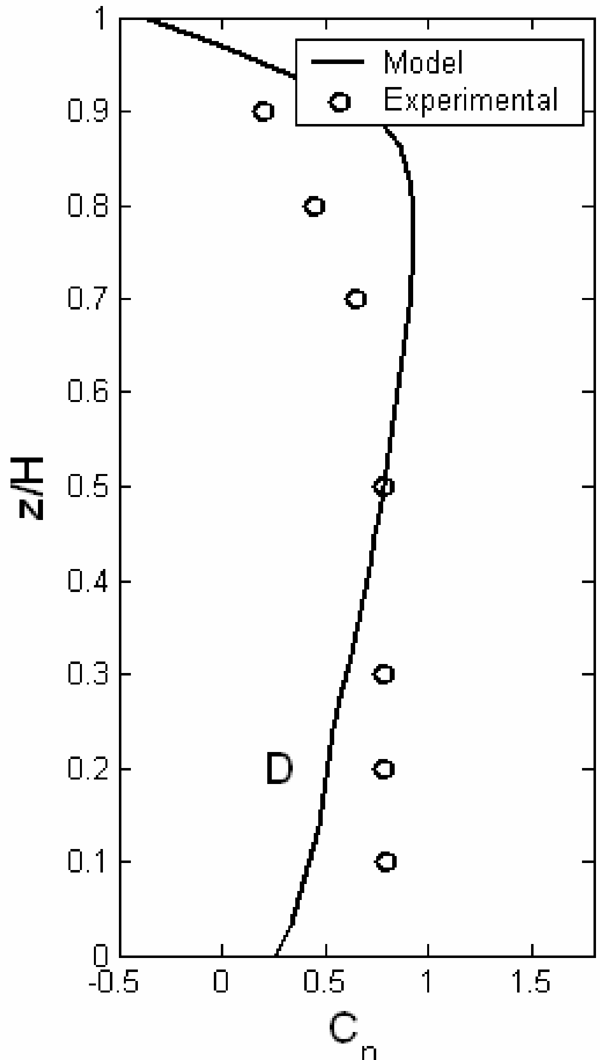
Adapted from
Gomes et al (2005)

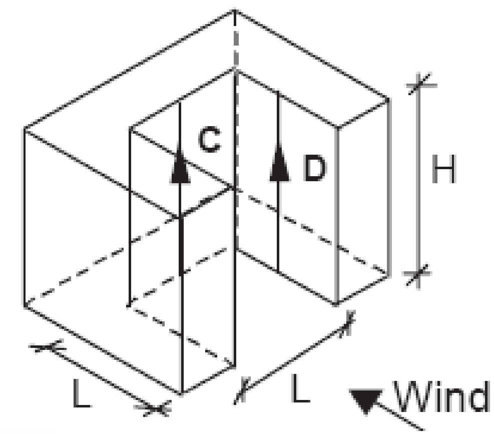
QUIC vs. Experimental Data: U-Shaped Building

Front Face A



Side Face B

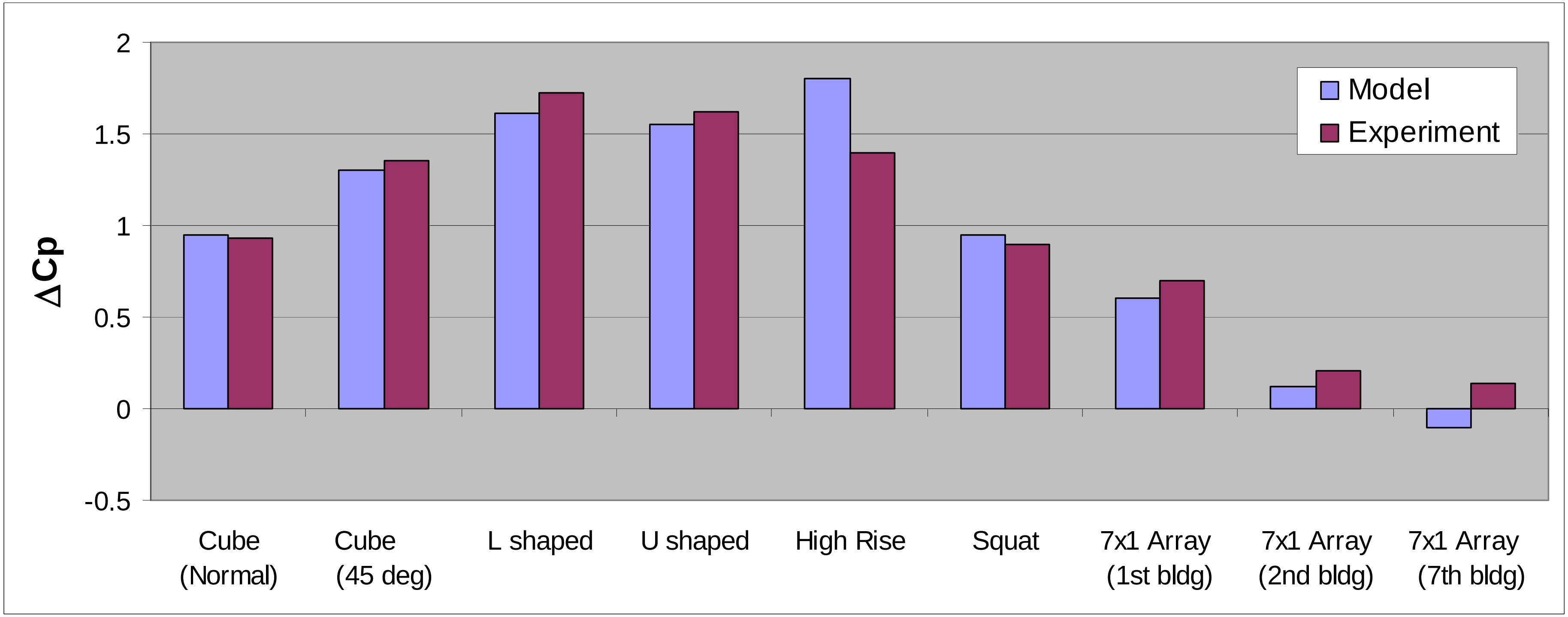




U-Shape

Adapted from
Gomes et al (2005)

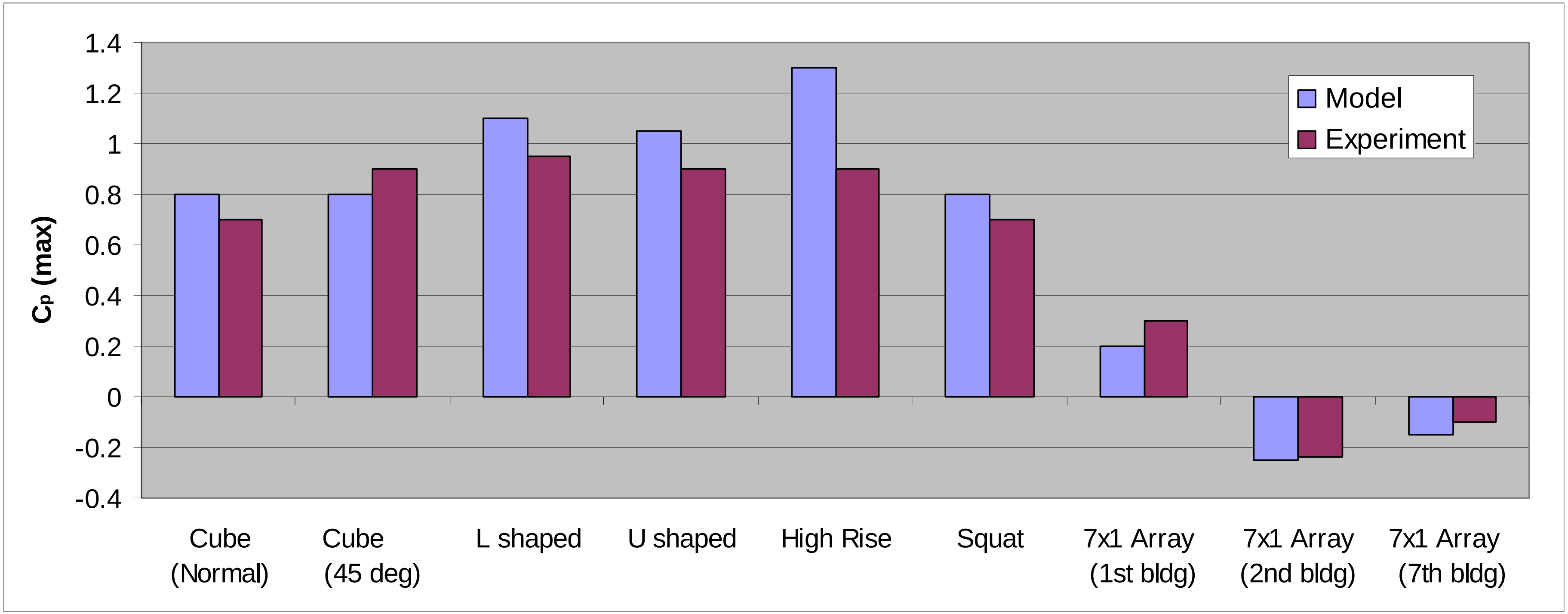
QUIC vs. Experimental Data



$$\Delta C_p = \text{Max } C_p \text{ Front Face} - \text{Min } C_p \text{ Back Face}$$

$$C_p = \frac{\overline{P} - \overline{P_o}}{\left(\frac{1}{2}\rho V_o^2\right)}$$

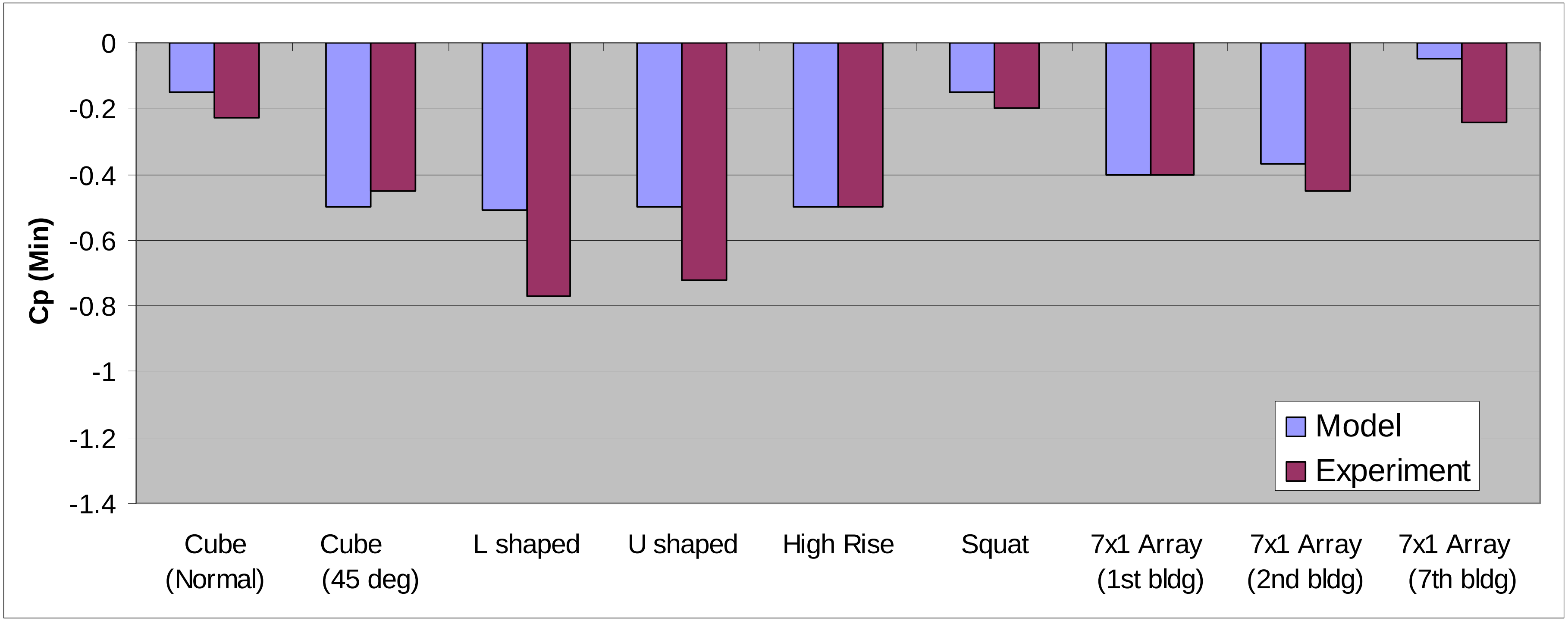
QUIC vs. Experimental Data



The Maximum C_p on the Front Face

$$C_p = \frac{\overline{P} - \overline{P_o}}{\left(\frac{1}{2}\rho V_o^2\right)}$$

QUIC vs. Experimental Data



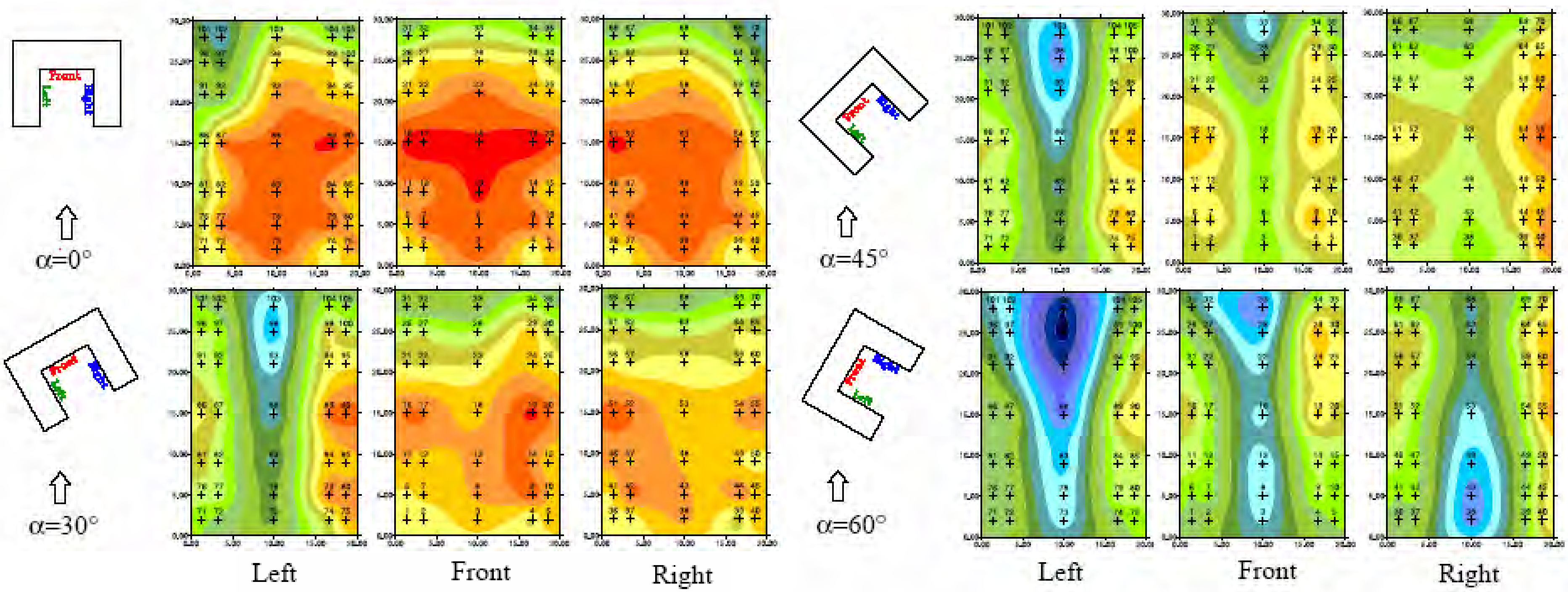
The Minimum C_p on the Back Face

$$C_p = \frac{\overline{P} - \overline{P_o}}{\left(\frac{1}{2}\rho V_o^2\right)}$$

Where the Combined Wind & Pressure Solvers Could Make a Difference

- Off-angle winds
- Dense Urban Areas - Sheltering effects of surrounding buildings
- Detailed analyses of building of interest (where locations of vents, windows, doors are known)

Off-Angle Winds

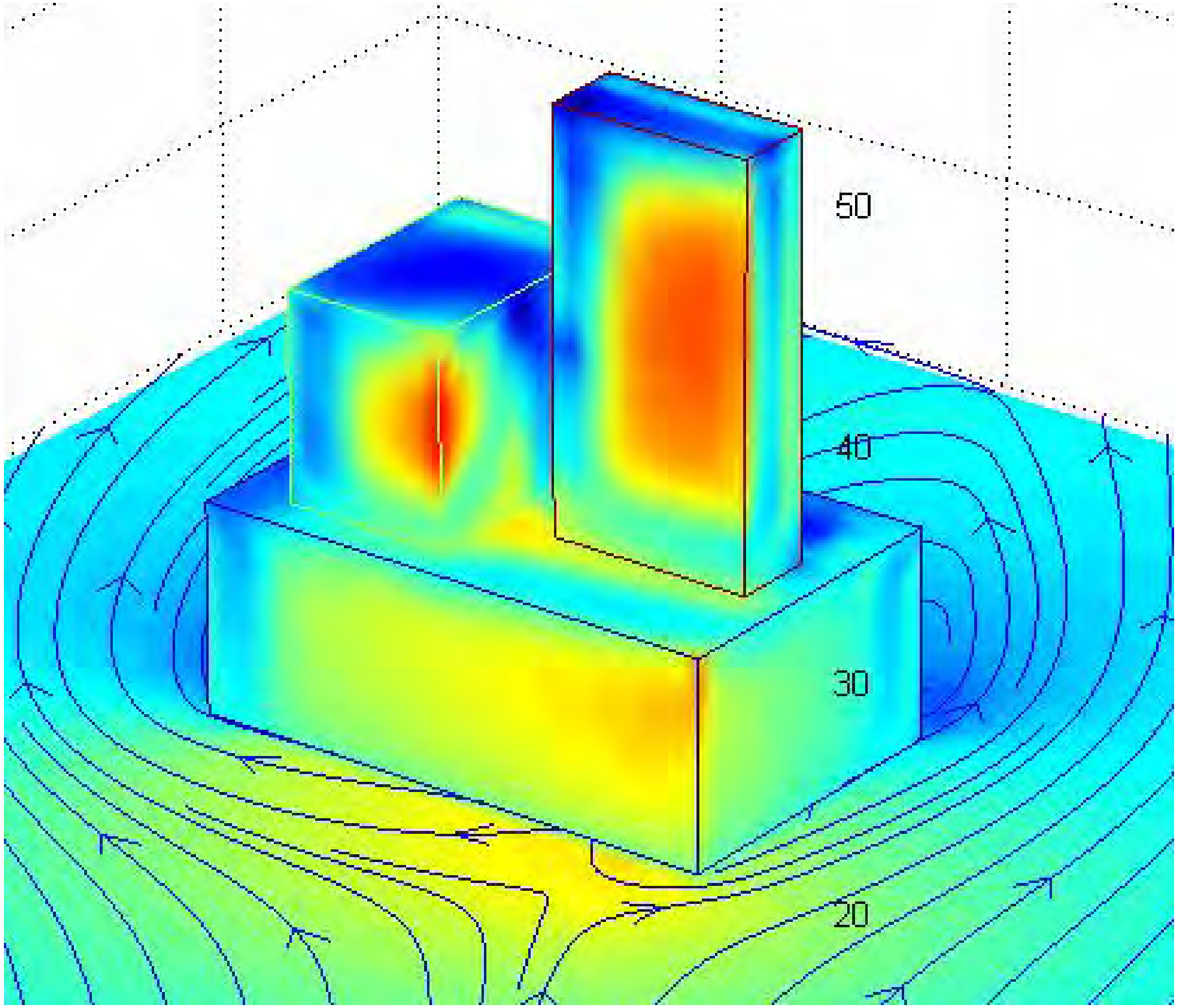


CFD simulations of Gomes et al. (2005)

Detailed Analyses of Buildings of Interest

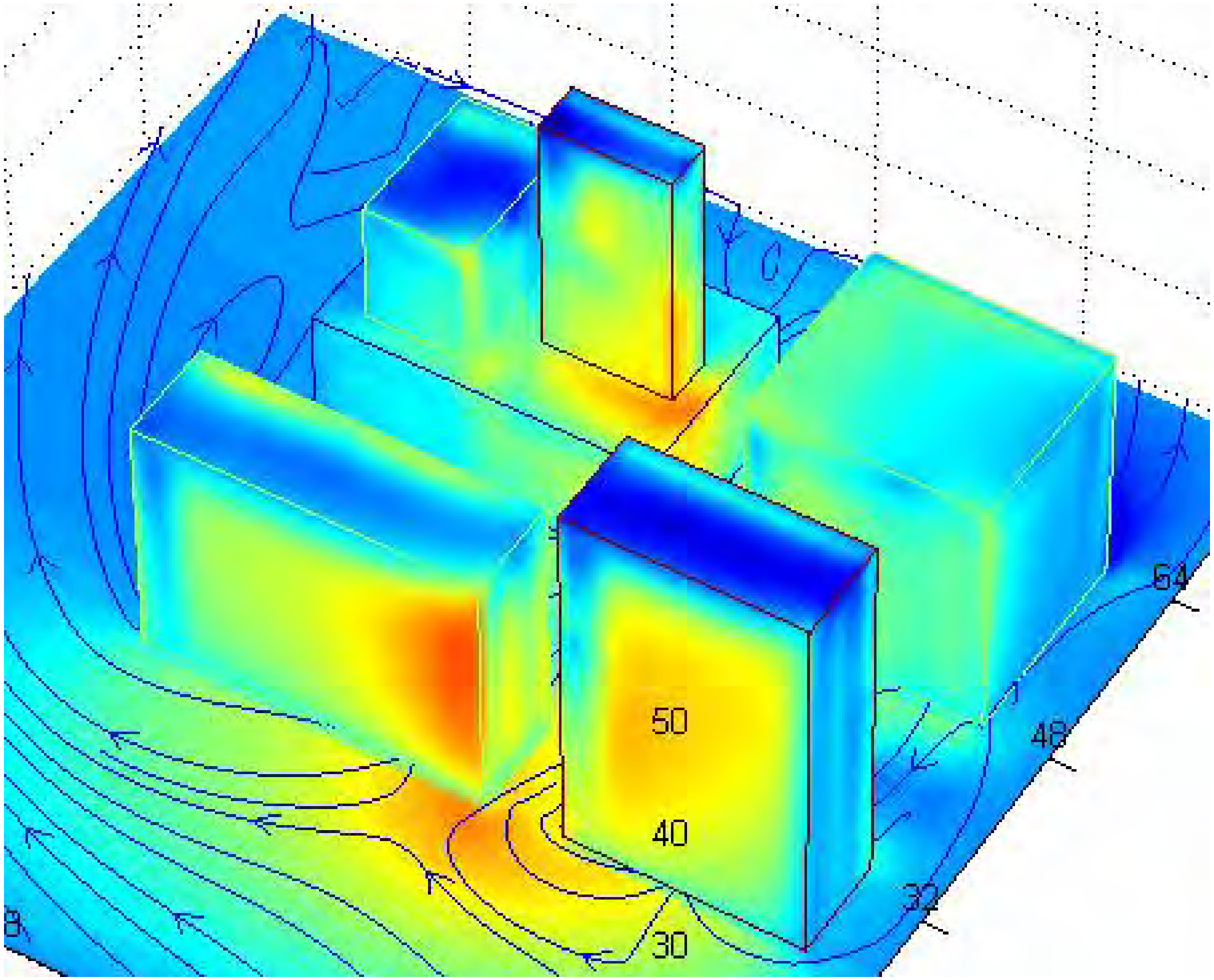
Specify pressure boundary conditions at inlets and outlets for control volume codes.

e.g., COMIS



Dense Urban Areas – Sheltering Effect

In city centers, buildings will have much lower natural ventilation rates due to obstruction of wind by surrounding buildings.



Dense Urban Areas – Sheltering Effect

In city centers, buildings will have much lower natural ventilation rates due to obstruction of wind by surrounding buildings.

Bauman et al (1988)
"Studies show wind pressure reductions of up to 90% resulting from wind blockage by upwind buildings. However, there is a variability of 80% depending on the configuration of the buildings."

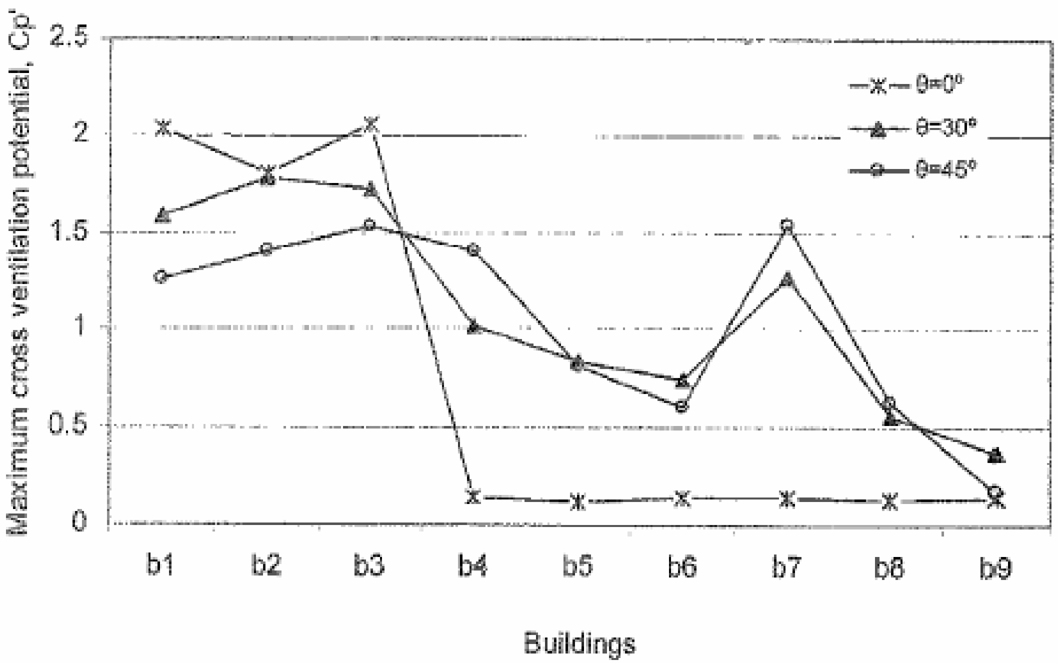


Figure 7. *Cp'* as a function of wind directions for the buildings in estate 1.

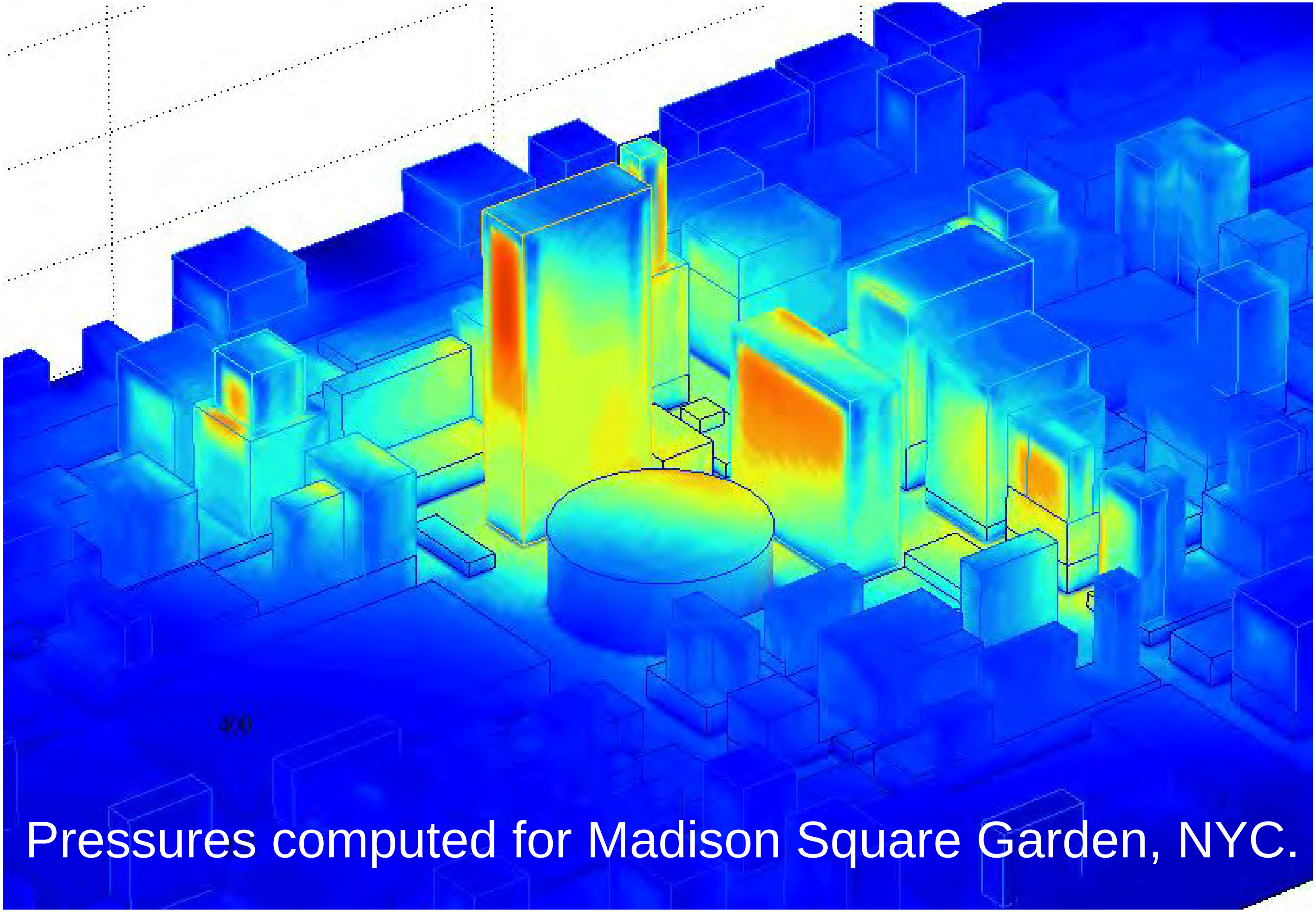
CFD simulations of Yang et al. (2005)

Dense Urban Areas – Sheltering Effect

Indoor models often have sheltering correction factors, e.g.,

UDM reduces the ΔP by a fixed amount if the building plan area density is above a specific threshold.

Dense Urban Areas – Sheltering Effect



Summary

- Wind-induced pressure information on buildings can be used to improve indoor dosage calculations (for outdoor and indoor releases)
- The QUIC wind and pressure solvers are relatively computationally inexpensive and would fit into a fast-response T&D modeling system
- Preliminary evaluation studies indicate that the QUIC wind and pressure solvers generally provide reasonable agreement with experimental studies

Technical Challenges

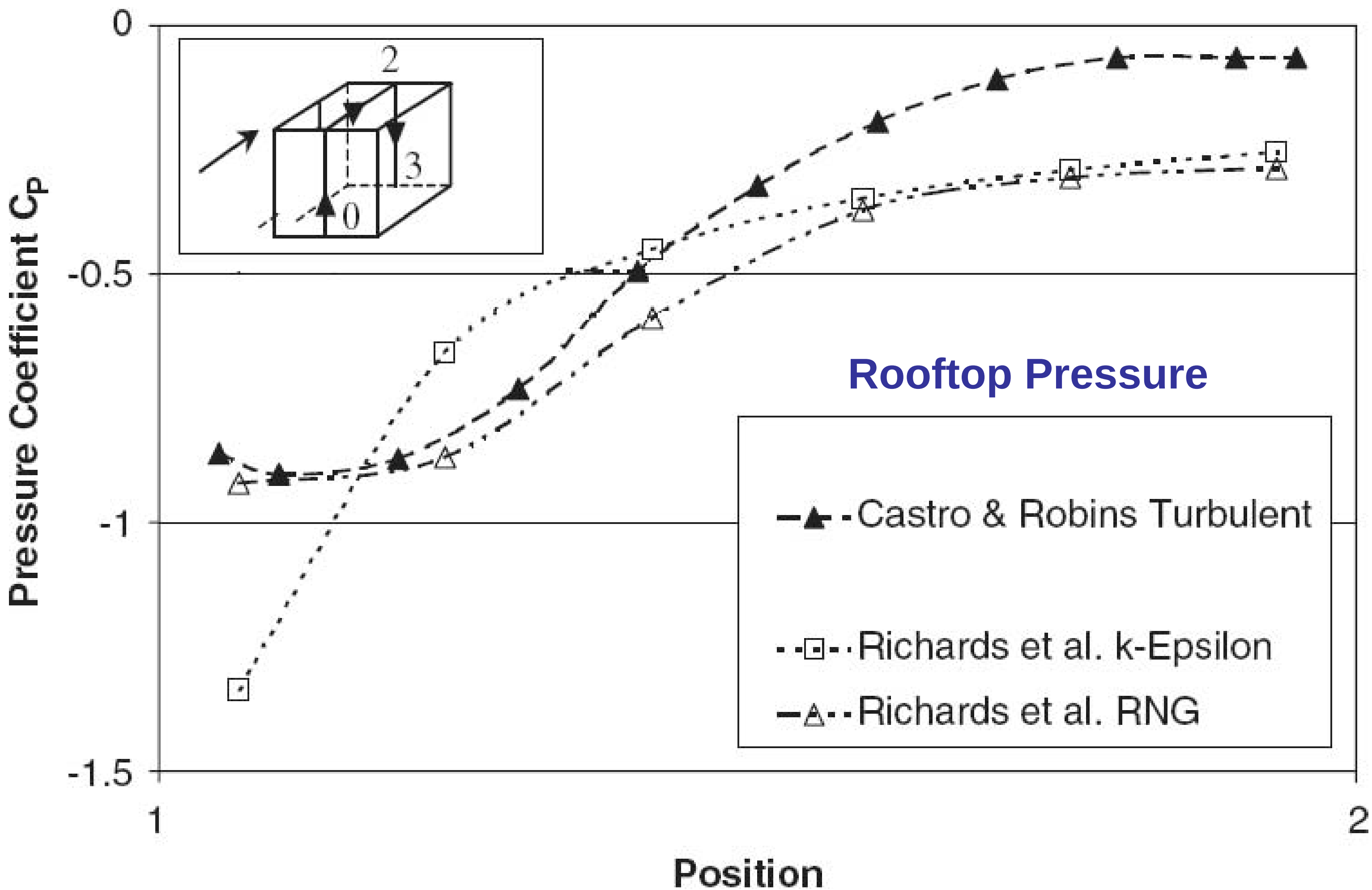
- Rooftop pressures on flat roofs difficult to match
- How about pitched roofs?
- Lack of experimental data in complex building environments
- Is turbulence important?

Acknowledgements

This work funded by the JSTO.

Special thanks to John Pace, John Hannan, and Rick Fry for the opportunity to perform this work.

CFD vs. Experimental Data



Adapted from Richards & Hoxey (2006)

RiskAware. solutions for life

Sensor Placement Algorithm for Rapid Theatre Assessment (SPARTA)

Presented by:

Dr Robert Gordon and Dr Martyn Bull

Risk aware
ISO 9001 Registered
UKAS 015

Introduction

- CB Sensors in Collective Protection Strategies
- Aims of Sensor Placement
- The SPARTA Approach
- Questions

Active Collective Protection Strategies

- Provide early warning of possible CB threat
- Information used to initiate threat response procedures such as
  - **Pre-Verification Actions** – event characterization
    - Source term estimation modeling
    - Hazard prediction modeling
  - **Verification Actions** – confirmation of threat
    - Multiple sensor integration
    - Integration over time
    - Visual observation
  - **Post-Verification Actions** – implementation of full collective protection strategy
  - **Post-Event Actions** – Decontamination / Forensics
    - Sensor data can be used to guide event reconstruction or determine effectiveness of decontamination efforts
- CB Sensors play critical role in Active Collective Protection Strategies

Problem Definition

"To determine how many CB sensors and where to place these CB sensors to provide the required level of protection for key assets while minimising the overall *cost*"

The Art Gallery Problem

- Introduced by Victor Klee in 1973
  - You have just bought an art Gallery and want to protect the contents from theft.
  - Where should the guards be positioned to ensure all assets are protected from theft.
  - What is the minimum number of guards required to provide complete coverage?

The Art Gallery Problem

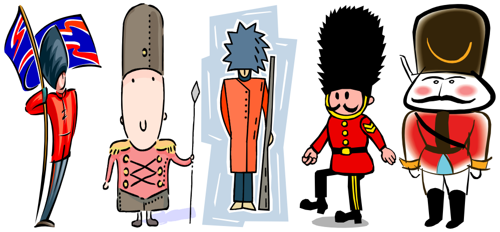
- Assumptions
  - Gallery defined as closed polygon
  - Unlimited number of prime quality guards available
  - Guards have continuous 360^{o} vision
  - There are no visitors
- Solution
  - Triangulation to determine maximum number of guards required
  - Optimisation to eliminate unnecessary guards

The Art Gallery Problem

- Closer match to CB sensor placement:
  - The gallery has no defined boundaries
  - Finite number of guards available
  - Each guard has different strengths and weaknesses
  - The guards can be unreliable
  - There are lots of visitors some which like to dress a bit like thief's
  - Assets can relocate
- Conclusion
  - By the time you figure our where best to place your guards, someone has stolen your Mona Lisa!






CB Sensor Placement Problem

- Continuous domain – complex varying environment
- Different sensor type – standoff and point, biological and chemical
- Use different sensing techniques
- Portability and size need to be considered
- Reliability considerations - prone to false alarms and nuisance alarms
- Cost considerations
- Timeliness – balancing the solution with the urgency

Aims of SPARTA Project

- To provide sensor placement capability that
  - Optimises the number and position of CB sensors to provide ‘best’ protection
  - Provides an incremental approach to building the problem complexity
  - Minimises computation times for the initial sensor placement

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SPARTA Approach

Key Development Goals

- Key functional requirements
  - Design deployments of multiple co-operating detectors (including detectors of multiple types)
    - Sensors combine to give maximum protection of assets
      - i.e. provide ***maximum probability*** of ***timely*** warning
  - Based on modelling of appropriate fidelity
    - Plume dispersion modelling
    - Sensor modelling
    - Downwind effects modelling

Key Development Goals (2)

- Key calculation input requirements
  – Spatial information
    - Key asset locations (from vulnerability assessment)
    - Likely threat locations (from threat assessment)
    - Sensor deployment cost information (from geography)
    - Other geographic data
  – Meteorology
    - Wind rose (or spatially varying wind data)

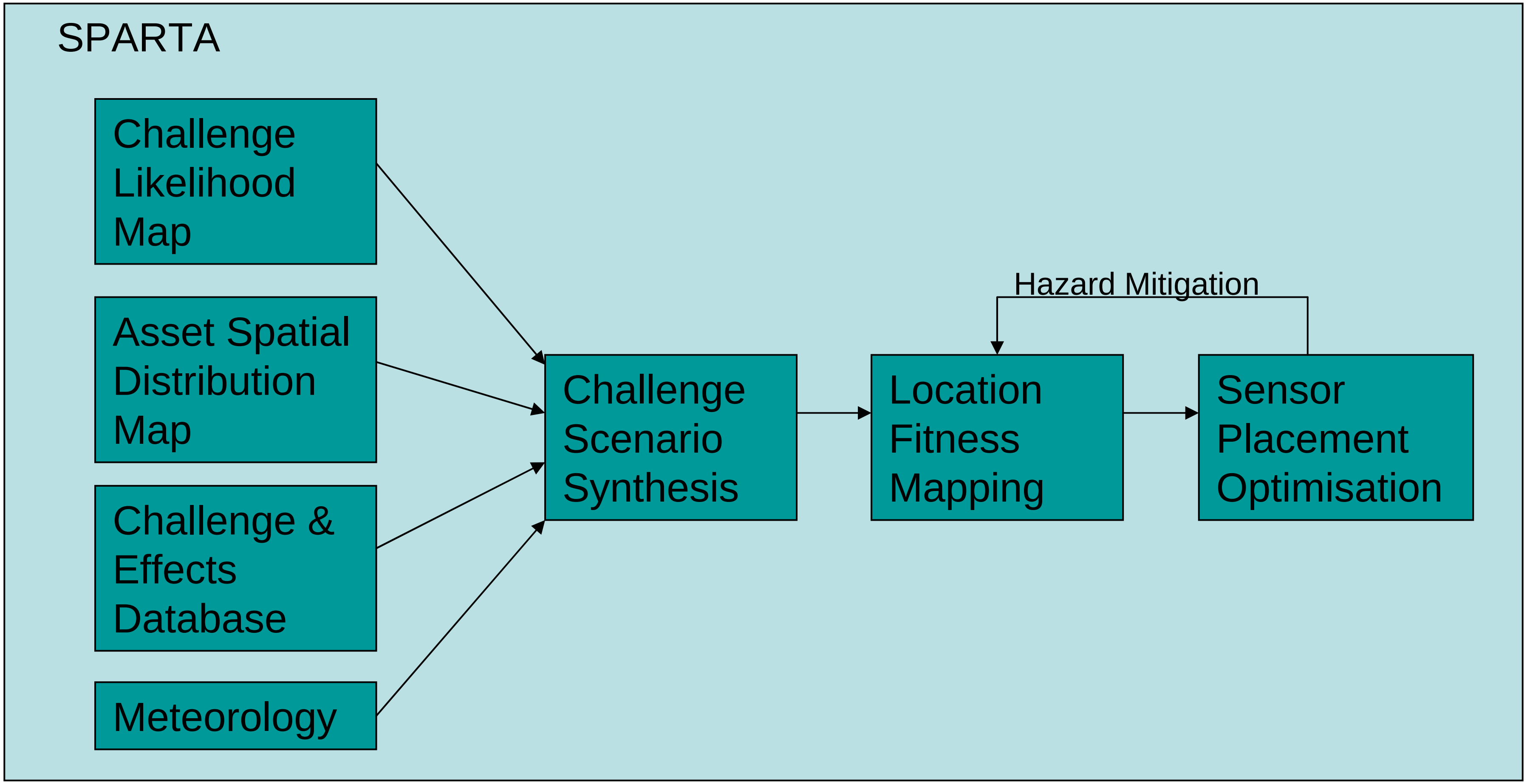
Key Development Goals (3)

- Key non-functional requirements
  - Rapid computation - 1-5 minute computation
    - (for practical in-theatre deployment)
  - Network-ready modular software design
  - Cross-platform deployment (Windows, Unix, etc.)

Sensor Placement Algorithm for Rapid Theatre Assessments (SPARTA)

- Modular calculation engine programmed in pure Java
  - Cross platform deployment
  - Designed for networked deployment
    - Visualisation via bespoke GUI, GIS, GOOGLE Earth, other options.
  - Based on existing physics-based modelling
    - Uses any suitable dispersion model
- Extensive pre-processing provides very rapid computation
  - 1 minute computation achieved for simple cases
  - Orders of magnitude (2+ orders) faster than “longhand” methods

SPARTA Technical Details – Data Flow



SPARTA Technical Details - Methodology

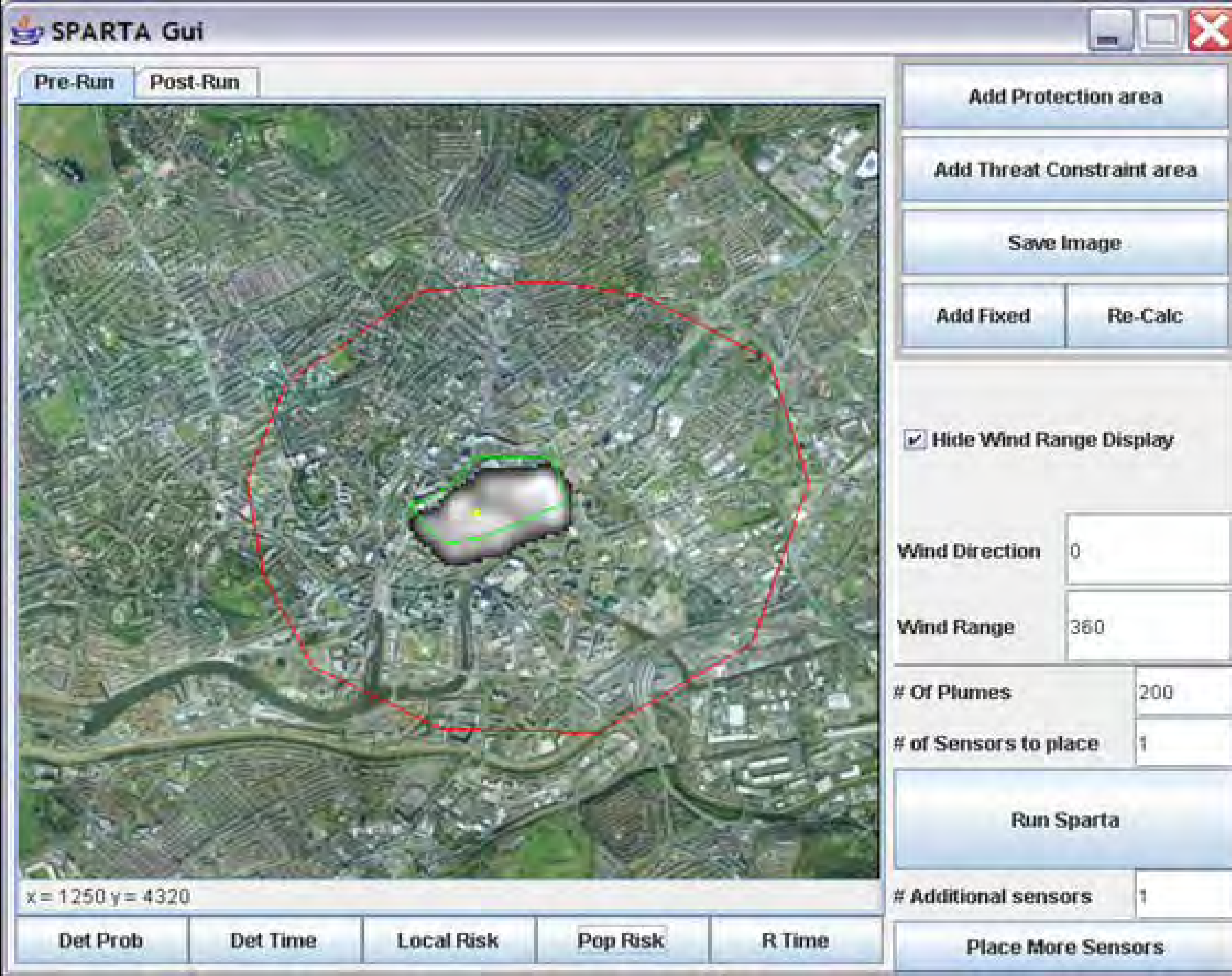
- Challenge/effects database
  - SPARTA uses a database of pre-run and pre-processed plumes from a 2nd order dispersion model such as SCIPUFF
  - Pre-processing (“thin slicing”) has been used to extract key information from plume
    - Hazard level map (% casualties)
    - Hazard “impact” time map
    - Detection probability map (for each detector type)
    - Detection timing map (for each detector type)
- Sensor location fitness calculation
  - Monte Carlo method used to create 000’s of challenge scenarios
  - **Robust** fitness measure for detector locations calculated
- Sensor placement optimisation
  - Sequential placement algorithm identifies “good” placements

SPARTA Technical Details – Detector Location Fitness

- The following data is used to calculate *smoothly varying* maps of detector location fitness:
  - Impact of each scenario on protected population/assets
    - Considers population density and hazard level
    - Supports raster (graded) or vector definition of protected asset locations
  - Probability of detection at proposed location
  - Timeliness of detection
    - i.e. time between warning and arrival for each protected asset location
  - “Cost” function of sensor location (raster or vector)
- Detector location fitness updated after each detector location is fixed
  - i.e. protected assets have their threat level reduced pro-rata by each sensor

SPARTA Technical Details – Position Optimisation

- A sequential placement scheme is adopted
  - Each successive sensor is placed at the best available location
  - Sensor location fitness is are adjusted via threat reduction
- A final test is performed on the overall placement
  - Weakest sensor locations are moved to better locations
- Sequential scheme is effective because fitness function is smooth and well behaved
- Other algorithms (e.g. Genetic Algorithm) could be added as post-processing stages for use if time allows


SPARTA Gui
Pre-Run
Post-Run
Add Protection area
Add Threat Constraint area
Save Image
Add Fixed
Re-Calc
Hide Wind Range Display
Wind Direction
0
Wind Range
360
Of Plumes
200
# of Sensors to place
1
Run Sparta
x = 1250 y = 4320
# Additional sensors
1
Det Prob
Det Time
Local Risk
Pop Risk
R Time
Place More Sensors

SPARTA Summary

- Calculation of sensor placement schemes on a 1-5 minute timescale IS achievable on current computation platforms
- Pre-processed plume database is instrumental in providing required performance gains
- A sequential placement scheme is efficient, and works well in combination with:
  - Smooth fitness function
  - Risk mitigation after each placement.
- Other algorithms (e.g. Genetic Algorithm) could be added as post-processing stages for use if time allows

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Questions?

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Improvement and Sensitivity Analysis of the Atmospheric Chemistry Module for Modeling TICs in SCIPUFF

Douglas S Burns, Veeradej Chynwat, William Moore, Jeffrey J Piotrowski, and Floyd Wiseman

ENSCO, Inc.

Science and Technology for Chem-Bio Information Systems (S&T CBIS)

January 11, 2007

Background

- **Phase I**
  - 9/03 – 9/05
  - "*Atmospheric Chemistry Module for TICs*"
  - Mike Henley, AFRL/MLQ Tyndall AFB, FL
- **Phase II**
  - 9/06 – current
  - "*Modeling the Atmospheric Chemistry of Toxic Industrial Chemicals*"

Outline

- **Background**
  - Project Goals
  - Phase I Status
- **Methodology**
  - Integration in SCIPUFF
  - Derivation of k_{eff} (example: 1-butene)
  - Parameter Space
- **Results**
  - Improved regression on k_{eff}
  - Model output
- **Summary**

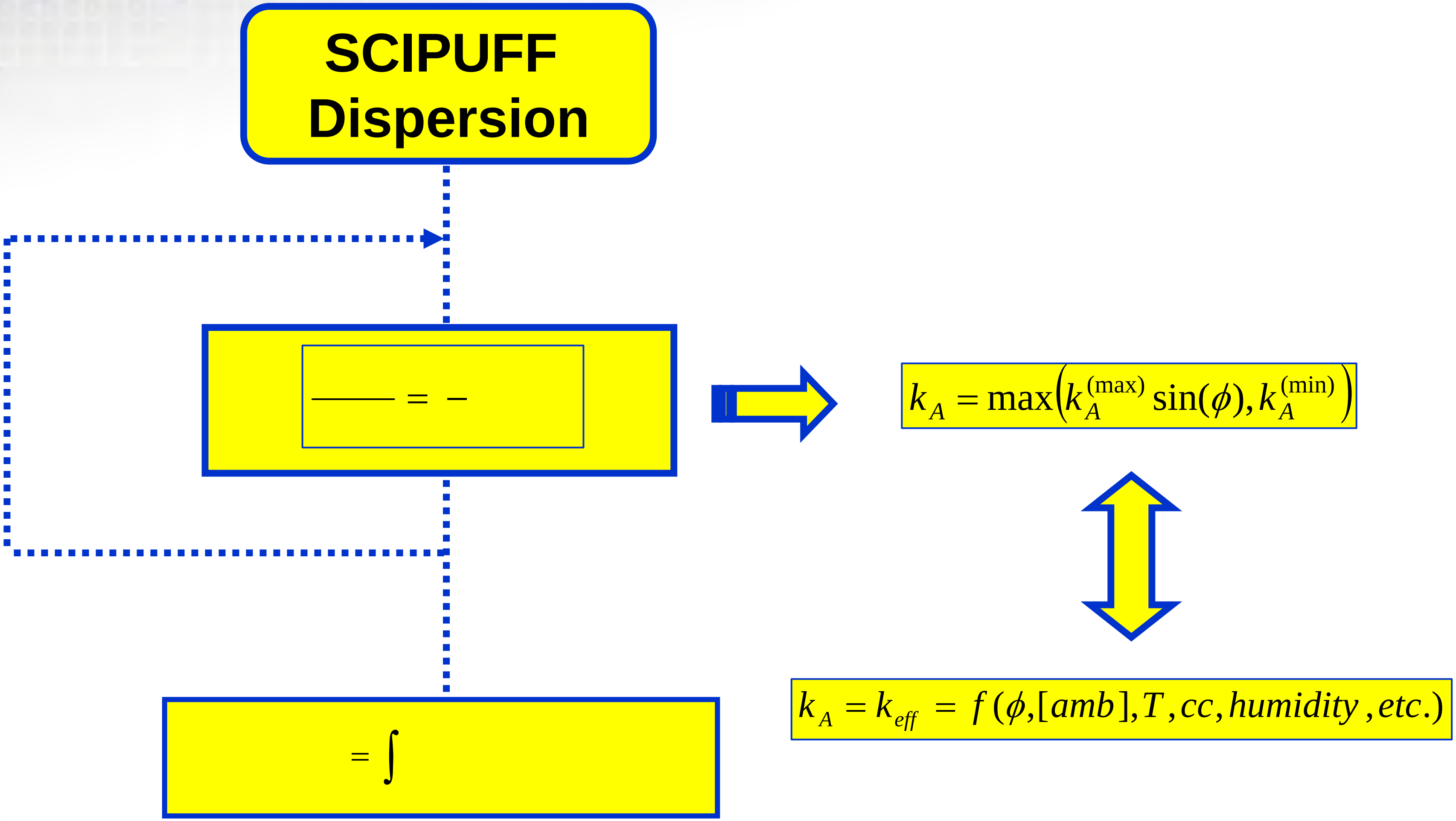
Project Goals

- **Develop initial atmospheric chemistry capability**
  - Develop Atmospheric Chemistry Algorithm
    - Algorithm MUST run rapidly.
    - Develop generic algorithm so that a detailed chemical kinetics approach is not required.
    - Algorithm must account for all (most) modeling scenarios (e.g., CC, T, ambient conditions).
    - Algorithm must be robust enough to account for diurnal changes to degradation rates.
    - Algorithm should account for the potential generation of intermediate toxic compounds.
  - Develop Chemical data for the Chemistry Algorithm
    - Review existing chemistry data for nine alkenes (and H_2S)
    - Develop mechanisms used to generate chemistry algorithm.
- **Couple Algorithm to SCIPUFF**
  - Work with Dr. Sykes to create interface with SCIPUFF
- **Launch Chemistry Module from HPAC**

Phase I Atmospheric Chemistry Modeling Capabilities

- Alpha code Delivered Feb 2005
  - Ability to model
    - reactant decomposition
    - product formation
  - Butene + Propanal (R and P)
- Beta code Delivered Sep 2005
  - 10 TICs (9 Alkene's + H_2S)
- No impact on wall-clock run time

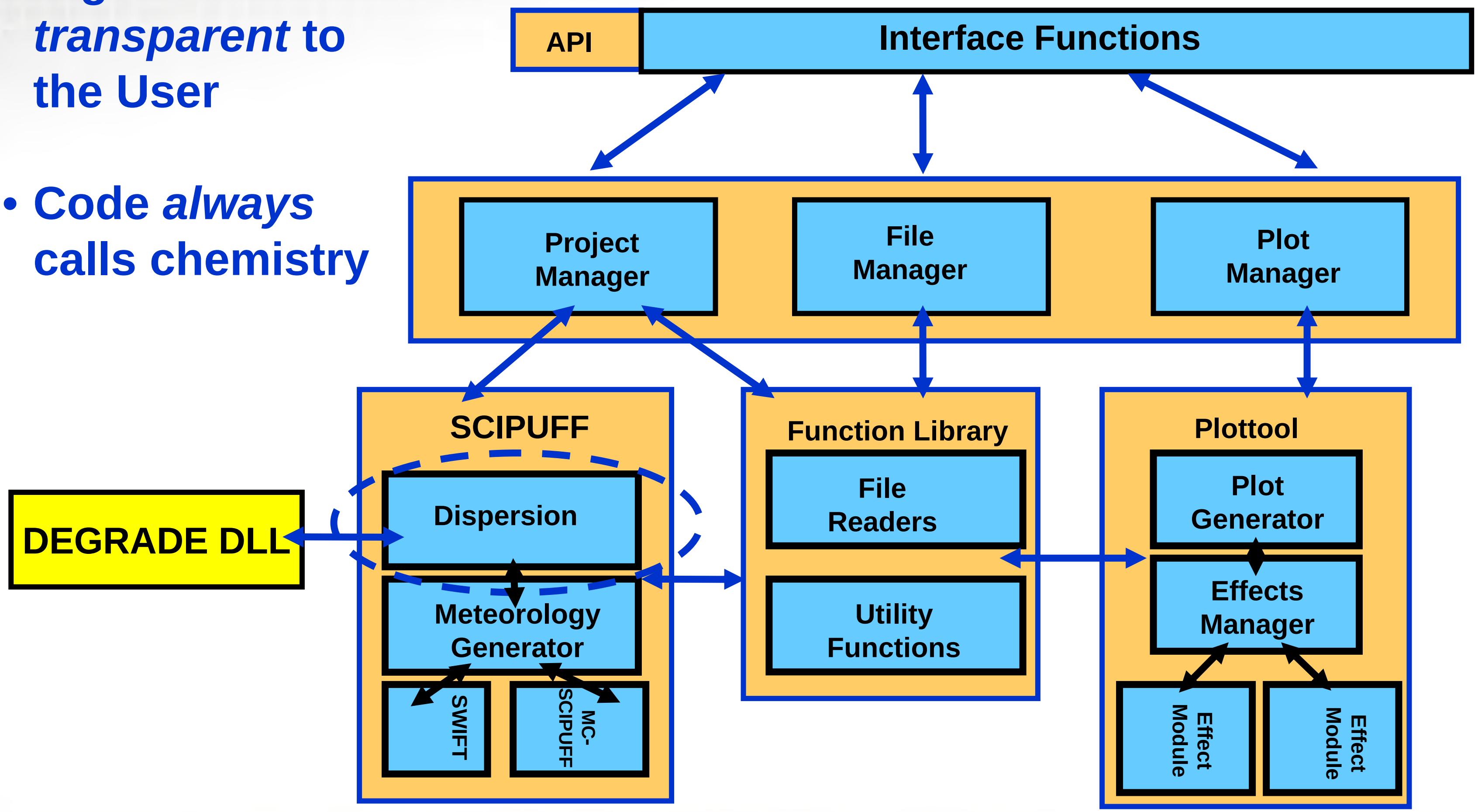
Methodology: Minor Modification to SCIPUFF



Method: Create Degrade Dynamic Link Library

Details in the Software Development Plan

- **Algorithm is *transparent* to the User**
- **Code *always* calls chemistry**



Methodology: Chemistry of 1-butene

$CH_2{=}CHCH_2CH_3 + OH \longrightarrow 0.94\ C_2H_5CHO + \text{Other products}$

$CH_2{=}CHCH_2CH_3 + NO_3 \longrightarrow 0.12\ C_2H_5CHO + 0.6\ C_3H_5O\text{-}CH\text{-}O\text{-}NO_2 + \text{Other products}$

$CH_2{=}CHCH_2CH_3 + O_3 \longrightarrow 0.35\ C_2H_5CHO + 0.41\ OH + \text{Other products}$

$$\text{Rate} = -\left(k_{OH}[OH] + k_{NO_3}[NO_3] + k_{O_3}[O_3]\right)\ [\text{1-butene}]$$

$$\text{Rate} = -k_{eff}\ [\text{1-butene}]$$

Methodology: Chemistry of 1-butene

Determine
ID Rxn's, E_A, k(T)
(w/ OH, NO_3, H_2O, O_3, etc.)

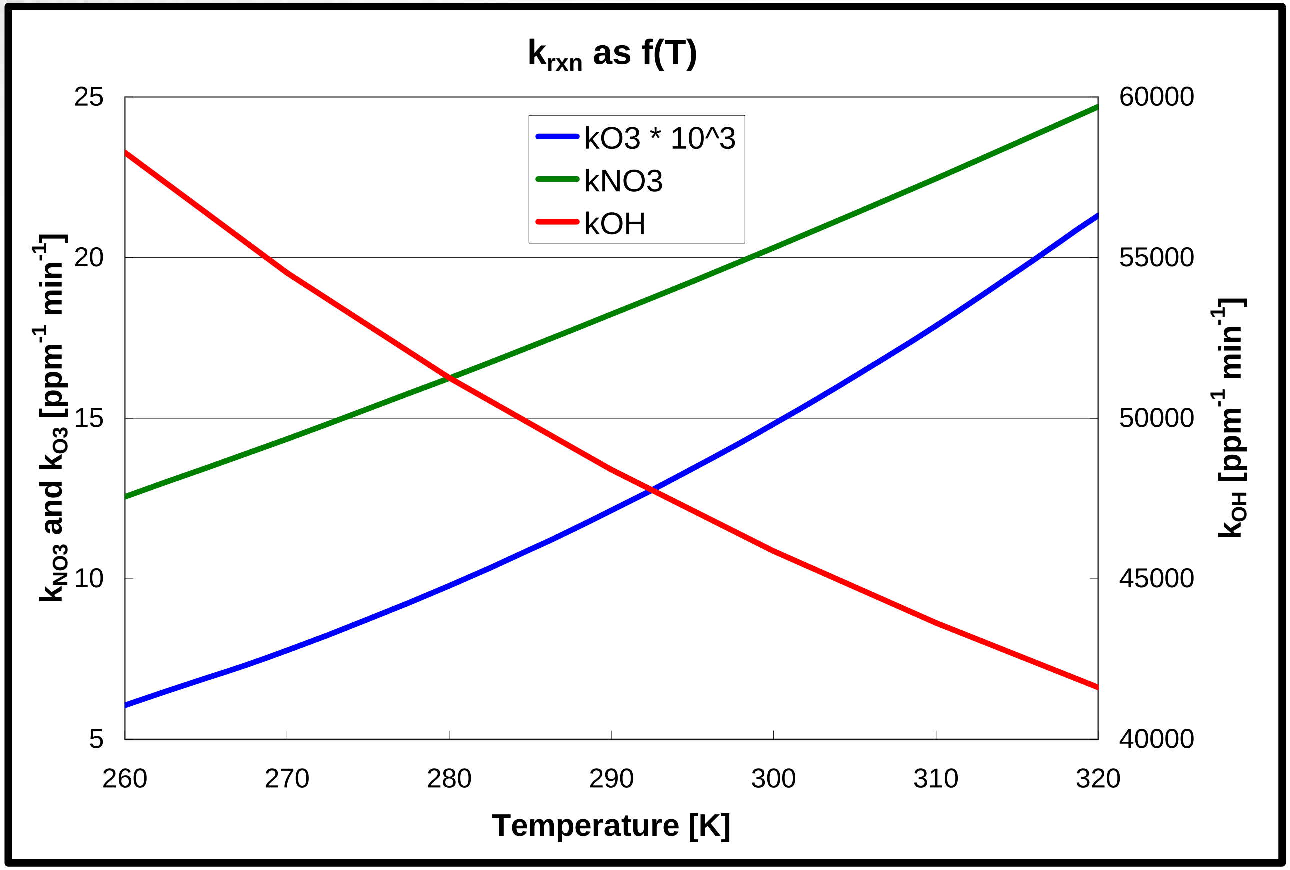
Implement in Detailed Mechanism

Run PBM as f(met parm's)

Obtain $c_{TIC}(t)$ as f(met parm's)

Derive Empirical k_{eff} (met parm's)

Populate SCIPUFF data tables w/ k_{eff} for TICs



Methodology: Detailed Mechanism

Determine
ID Rxn's, E_A, k(T)
(w/ OH, NO_3, H_2O, O_3, etc.)

↓

Implement in Detailed Mechanism

↓

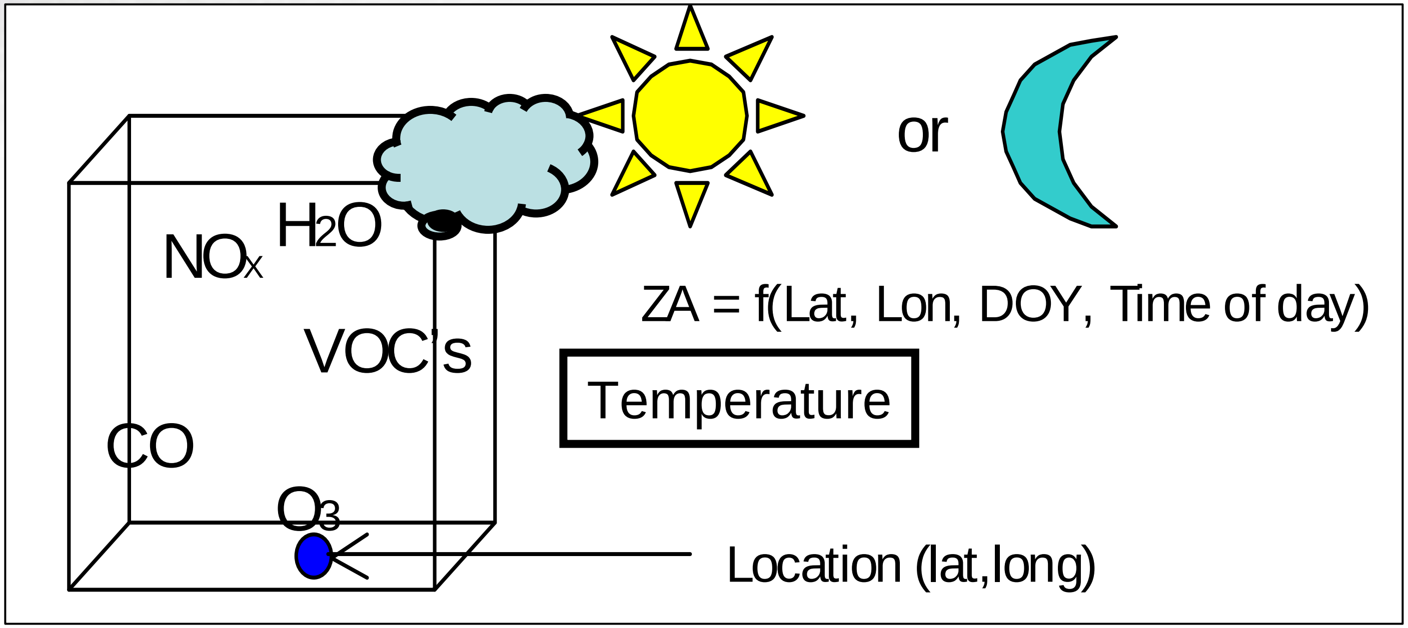
Run PBM as f(met parm's)

↓

Obtain c_{TIC}(t) as f(met parm's) → Derive Empirical k_{eff} (met parm's) → Populate SCIPUFF data tables w/ k_{eff} for TICs

- **Carbon Bond Mechanism**
  - Mass consistent atmospheric chemistry mechanism.
  - EPA Model (Adelman, 1999).
  - Used to model the ambient conditions.
  - [OH], [NO_3], [O_3], NO_X, VOCs, etc.
- **Append chemistry for TIC**
  - Data provided for 9 alkenes and H_2S

Methodology: Run Detailed Chemistry



k_{eff} is a function of solar elevation, cloud cover, air quality, temperature, humidity, etc

Implement in Detailed Mechanism → **Run PBM as f(met parm's)** → **Obtain $c_{TIC}(t)$ as f(met parm's)** → **Derive Empirical k_{eff} (met parm's)** → **Populate SCIPUFF data tables w/ k_{eff} for TICs**

Methodology: Parameter Space

Parameter	Units	SCIPUFF
Solar Zenith Angle	0 – 90 Deg	**X**
Location (**lat**, lon)	0 – 70 Deg	**X**
Time of Day	1440 min	**X**
Day of Year	3/21, 6/20, 12/20	**X**
Photochemistry (**Cloud Cover**)	0 – 8 Eighths	**X**
Temperature	**230 – 310 K**	**X**
Water Concentration	**100 – 40000 PPM**	
Moisture Mixing ratio		**X**
Air Quality	$[NO_X]$, VOC, O_3, …	
Land Use	Urban, ocean, forest, …	**X**

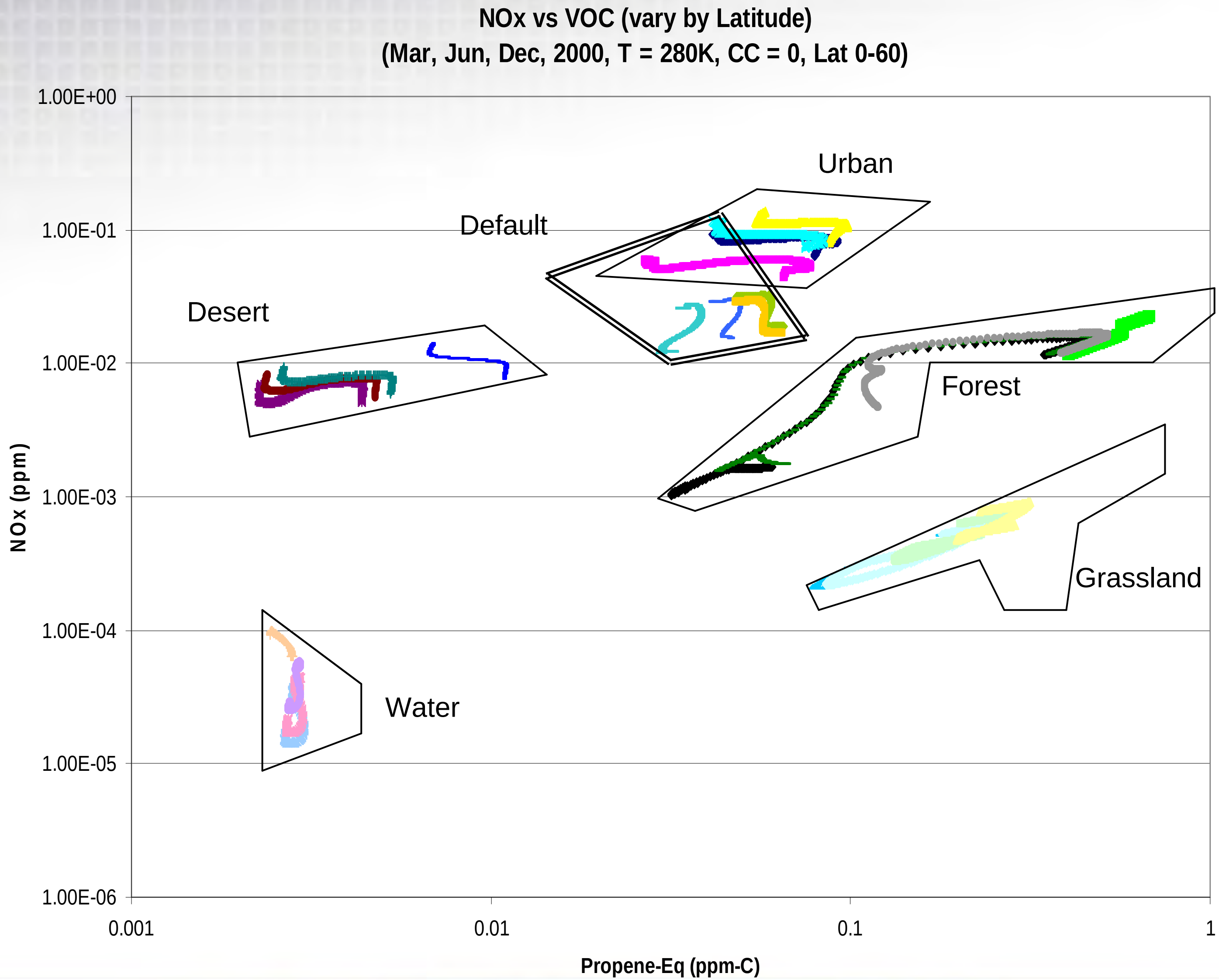
Methodology: Surrogate for Air Quality

- **Land Use**

1=Developed
2=Dry Cropland & pasture
3=Irrigated Cropland
5=Cropland/Grassland
6=Cropland/Woodland
7=Grassland
8=Shrubland
9=Shrubland/Grassland
10=Savanna
11=Deciduous Broadleaf
12=Deciduous Needleleaf
13=Evergreen Broadleaf
14=Evergreen Needleleaf
15=Mixed Forest
16=Water
17=Herbaceous Wetland
18=Wooded Wetland
19=Barren
20=Herbaceous Tundra
21=Wooded Tundra
22=Mixed Tundra
23=Bare Tundra
24=Snow or Ice
25=Partly Developed

1001=Urban Superclass
1002=Grassland Superclass
1003=Forest Superclass
1004=Desert Superclass
1005=Water Superclass

Methodology: Surrogate for Air Quality



Methodology: Refined Parameter Space (T, H_2O)

- **Surface Stations Nov 2003 – Sep 2004.**
- **Global 0.5 km LU Data Set**

1. Extracted data using 3 hr interval instead of 30 sec data. (both day and night)
2. Removed extreme data points (i.e., T<-60 °C or T<Dew point).
3. Matched weather station data with LU data before analysis (5 categories).

Latitude	Temperature (K)		$[H_2O]$ ($\times 10^3$) ppm)	
	Min	Max	Min	Max
0	288	310	12.4	37.1
10	288	310	7.05	37.4
20	288	310	4.55	37.1
30	274	310	3.81	34.9
40	265	304	1.54	28.5
50	257	299	1.02	19.8
60	245	294	0.400	14.2
70	231	291	0.113	11.6

Methodology: Run Detailed Chemistry

$$r_i = \left(-\frac{\partial c_i}{\partial t} \right)_{Chemistry} = -k_{OH}[OH][c_i] - k_{NO_3}[NO_3][c_i] - k_{O_3}[O_3][c_i] - k[c_i] - \ldots..$$

$$-\left(\frac{dc_i}{dt} \right)_{chemistry} = k_{eff}[c_i]$$

$$k_{eff} = \frac{-\frac{dc}{dt}}{[c]}$$

Implement in Detailed Mechanism

↓

Run PBM as f(met parm's)

↓

Obtain $c_{TIC}(t)$ as f(met parm's)

→

Derive Empirical k_{eff} (met parm's)

→

Populate SCIPUFF data tables w/ k_{eff} for TICs

Methodology: Obtain C_{TIC} as f(t)

$$k_{eff} = \frac{-\frac{dc}{dt}}{[c]}$$

Implement in Detailed Mechanism

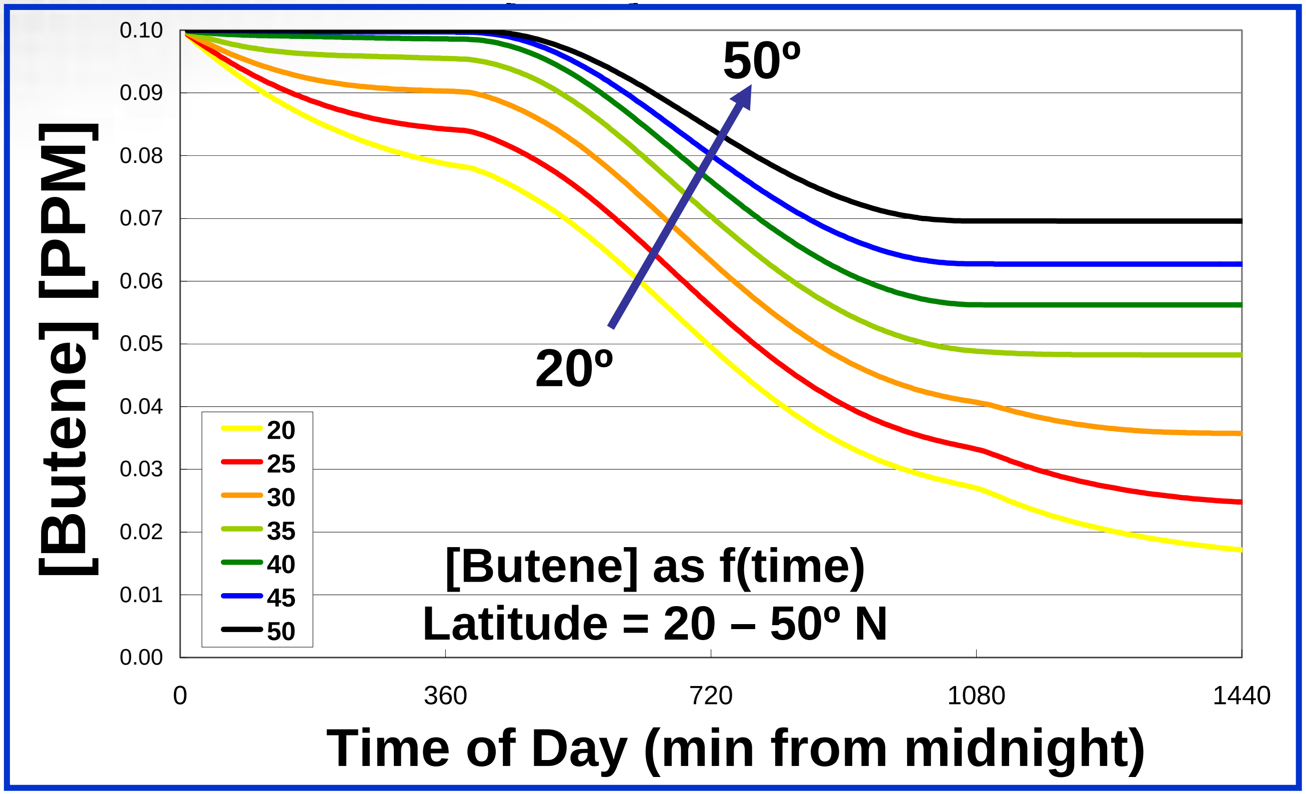
Run PBM as f(met parm's)

Obtain $c_{TIC}(t)$ as f(met parm's)

Derive Empirical k_{eff} (met parm's)

Populate SCIPUFF data tables w/ k_{eff} for TICs

T = 290 K, Land Use = Urban



Methodology: Obtain k_{eff} as f(met parms)

$$k_{eff} = \frac{-\frac{dc}{dt}}{[c]}$$

Implement in Detailed Mechanism

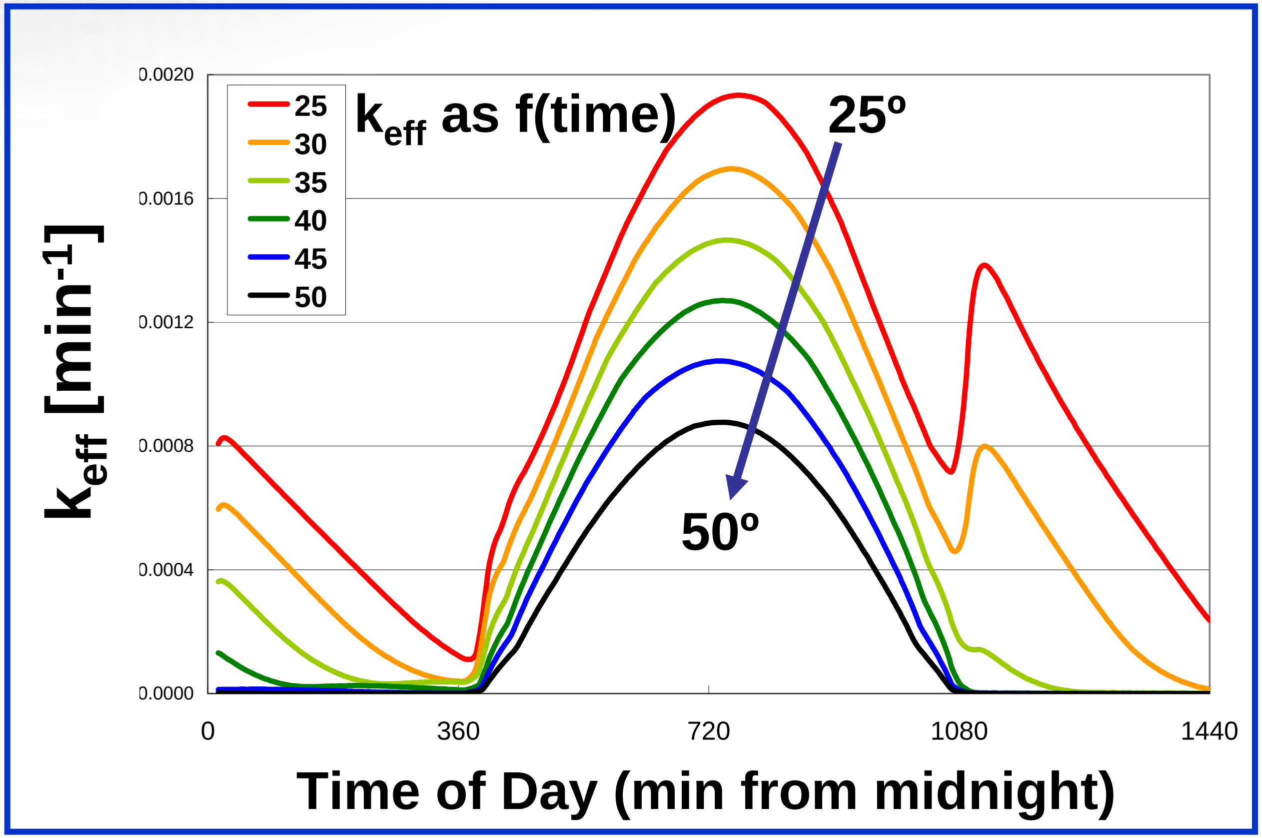
Run PBM as f(met parm's)

Obtain $c_{TIC}(t)$ as f(met parm's)

Derive Empirical k_{eff} (met parm's)

Populate SCIPUFF data tables w/ k_{eff} for TICs

T = 290 K, Land Use = Urban



Phase I Methodology: Derive Empirical k_{eff}

- Generate k_{eff} for various combinations of meteorological parameters for each land use
- Transform data to center on all parameters
- Perform statistical regression - correlation
  - Review Equation
  - Review Statistical Parameters (e.g., r^2)
  - Weigh fit vs number of parameters
- Derive an empirical k_{eff} = f(SE, T, lat, tod, CC, [H_2O])
- Compare the k_{eff} (empirical model) with the PBM derived k_{eff}.

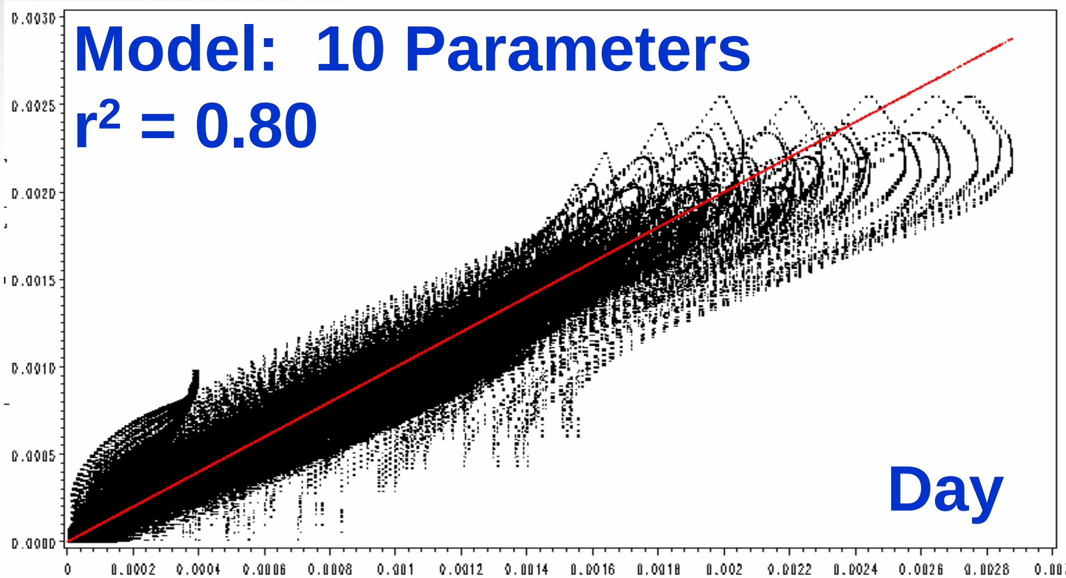
Obtain c_{TIC}(t) as f(met parm's) → **Derive Empirical k_{eff} (met parm's)** → **Populate SCIPUFF data tables w/ k_{eff} for TICs**

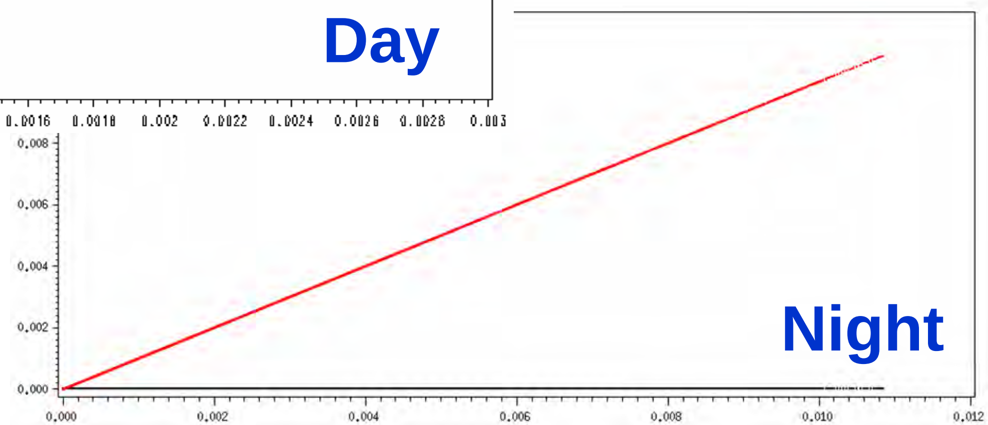
Results: k_{eff} (polynomial) vs k_{eff} (PBM) for butene

Land Use = Urban

> 500,000 points

k_{eff} [min^{-1}] from Polynomial





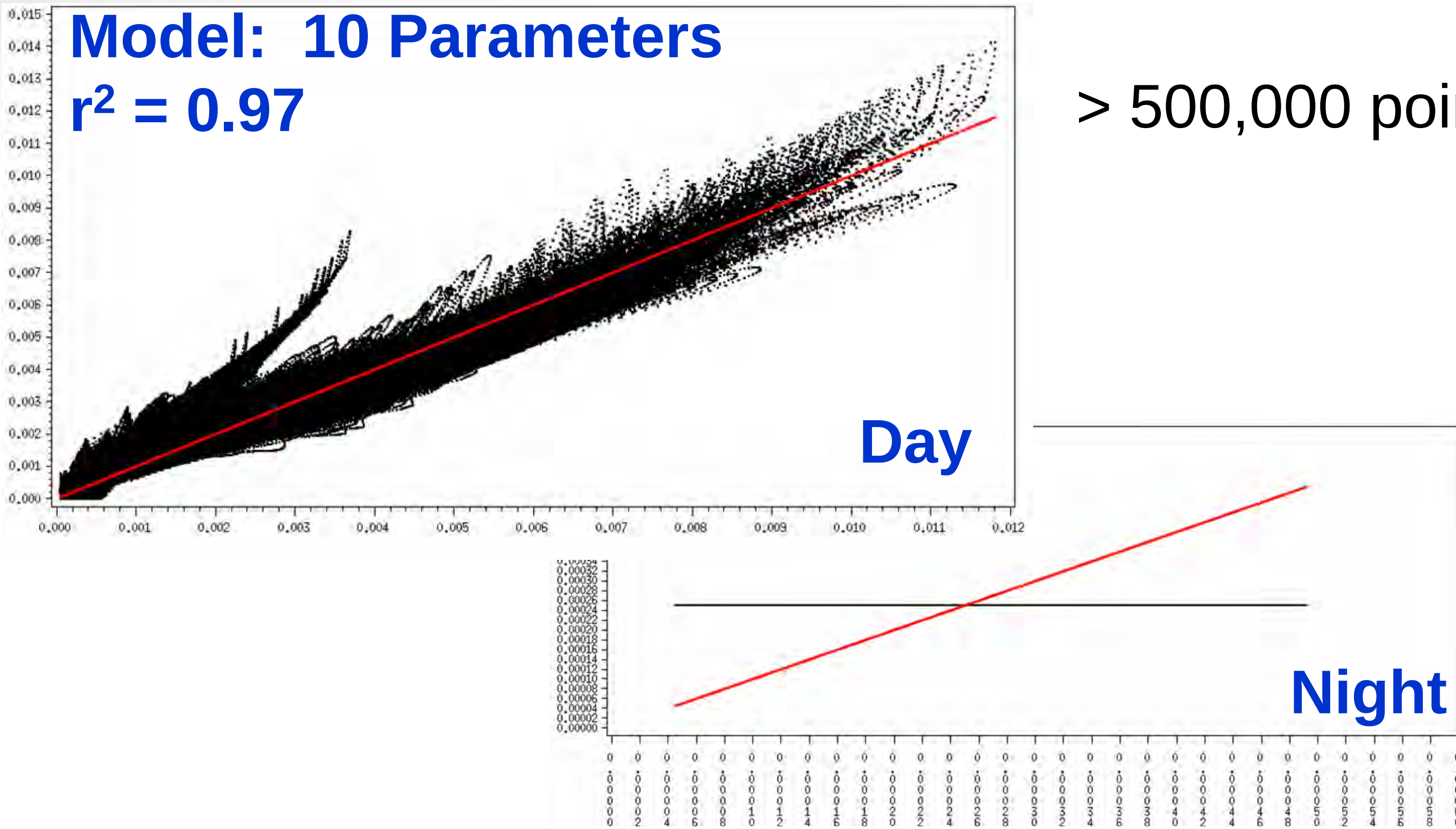
k_{eff} [min^{-1}] from PBM

Results: k_{eff} (polynomial) vs k_{eff} (PBM) for butene

Land Use = Water

> 500,000 points

k_{eff} [min^{-1}] from Polynomial



k_{eff} [min^{-1}] from PBM

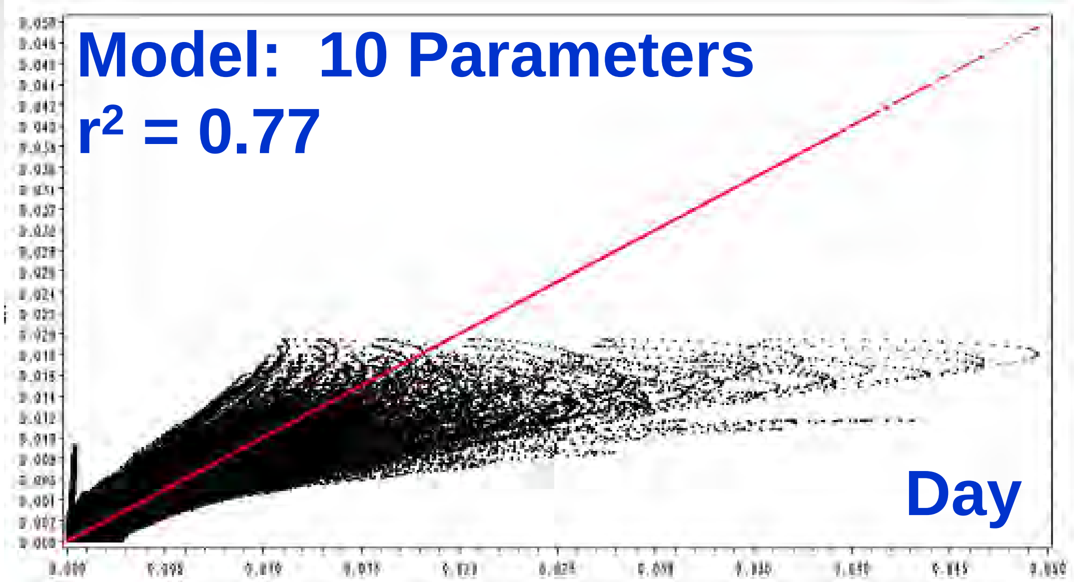
Results: k_{eff} (polynomial) vs k_{eff} (PBM) for butene

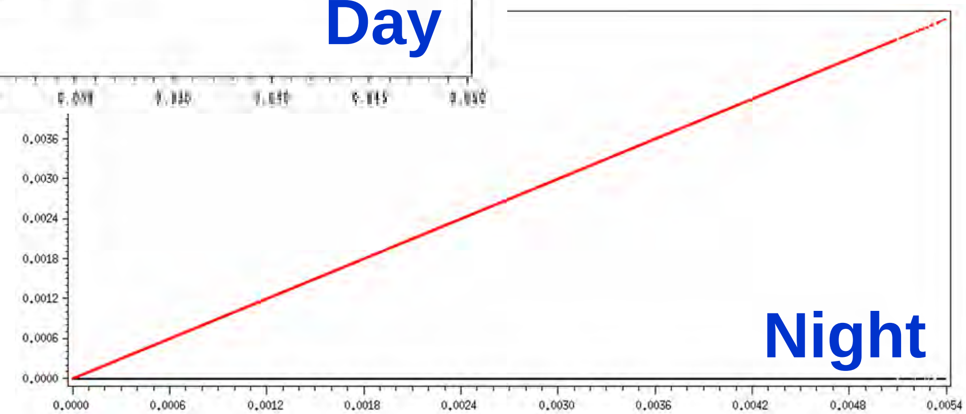
Land Use = Forest

Model: 10 Parameters

$r^2 = 0.77$

> 500,000 points





k_{eff} [min^{-1}] from Polynomial

k_{eff} [min^{-1}] from PBM

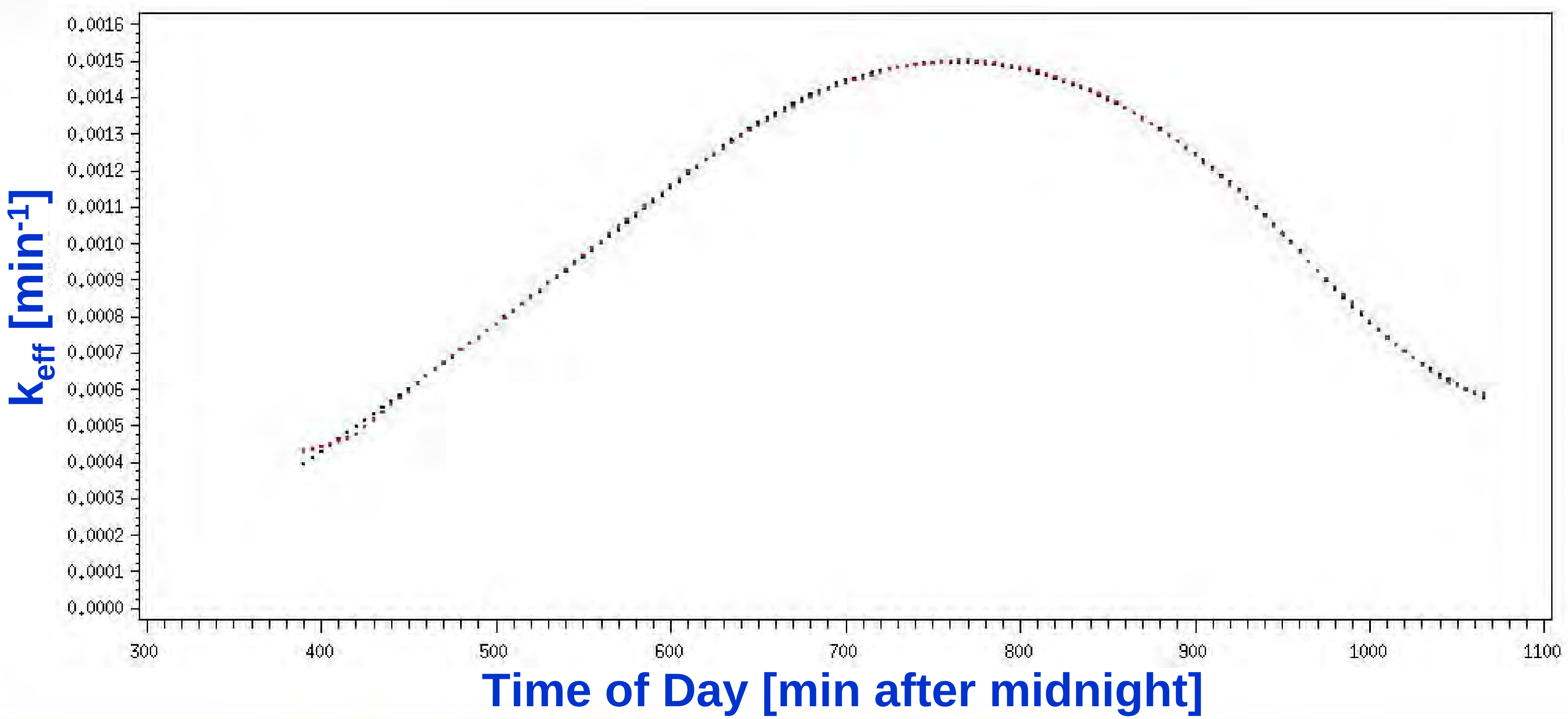
Current Effort – Improve Regression Analysis

- **Goal:**
  - Obtain better correlation with fewer fitting parameters for k_{eff}.
- **Method:**
  - Daytime (SE > 5°)
    - Fit polynomial spline for the 4104 unique combinations of latitude, temperature, cloud cover, and humidity
    - 7 parameter estimates for each combination used to estimate k_{eff} for a given time.
  - Nighttime (SE < 5°)
    - Data for each time span before sunrise and after sunset were divided into quartiles.
    - Average k_{eff} calculated for each of the eight quartile.
- F90 code written to ingest lat, T, CC, Humidity, and Time.
  - Interpolate k_{eff} values that lie between parameter values.
  - Will become the new degrade.dll code once completely tested.
  - Must verify run-time performance

Results: k_{eff} (spline) vs Time of Day for butene

Land Use = Urban

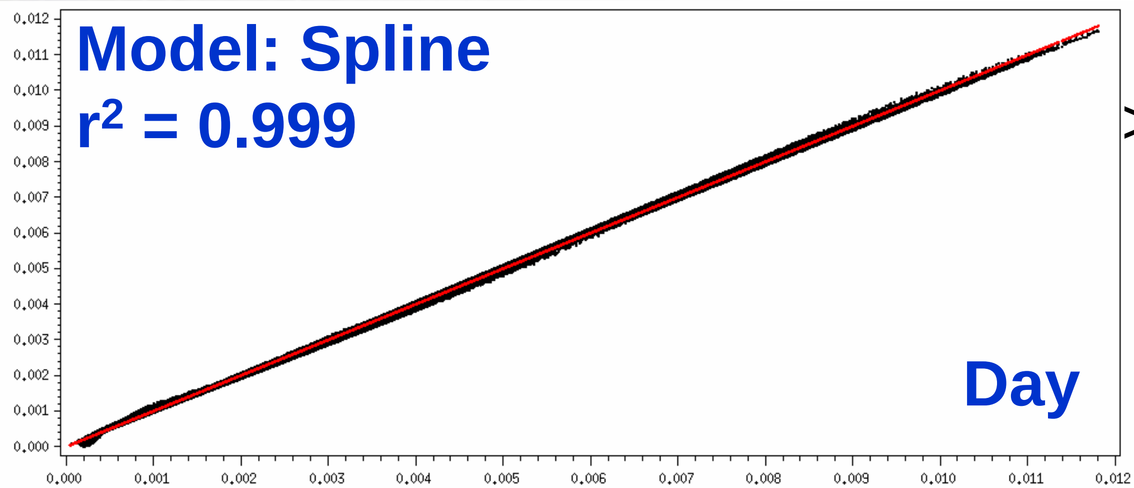
Lat 0°, Temp 311 K, Cloud Cover 0/8, $[H_2O]$ = 37000 ppm,



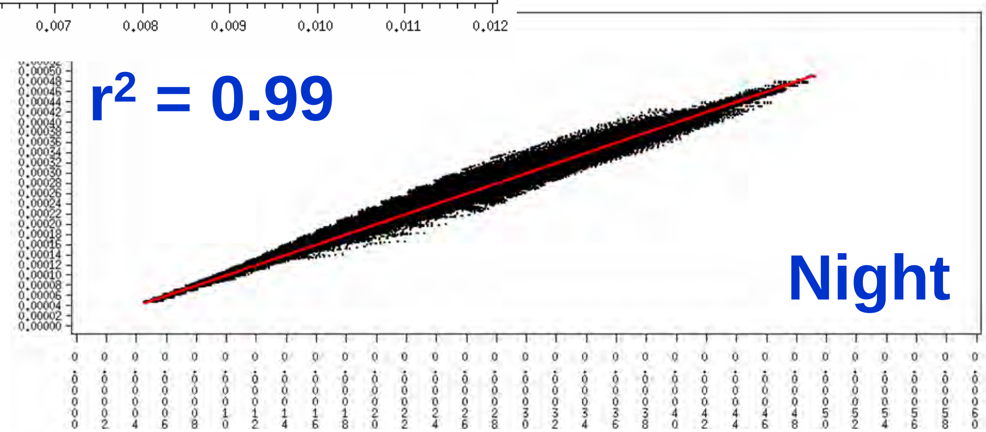
Results: k_{eff} (spline) vs k_{eff} (PBM) for butene

Land Use = Water

k_{eff} [min^{-1}] from Spline Fit



> 500,000 points



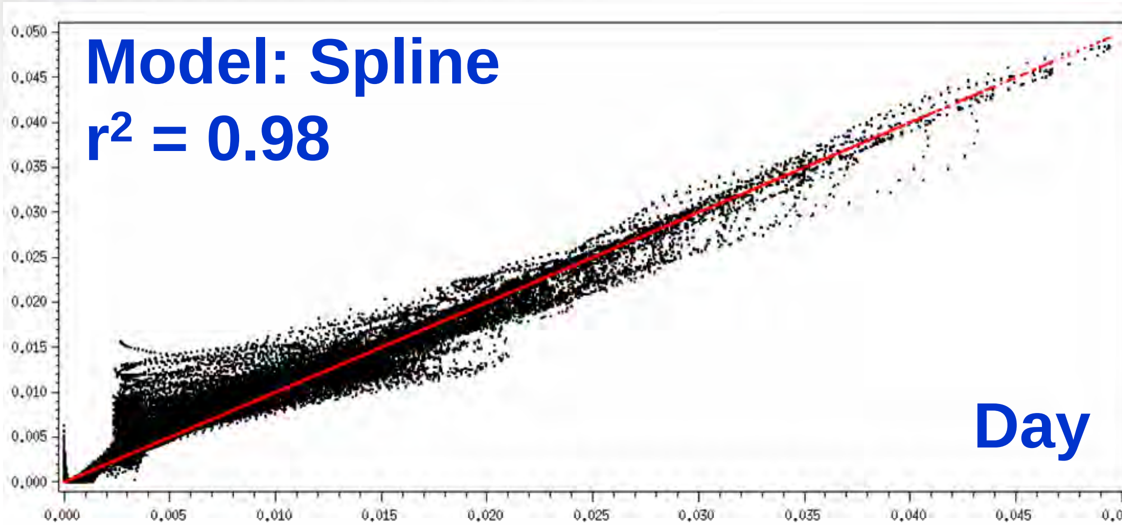
k_{eff} [min^{-1}] from PBM

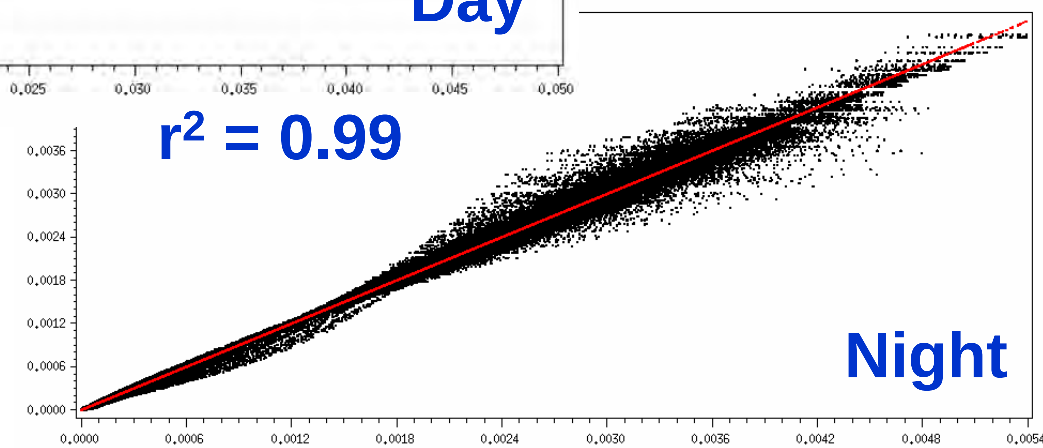
Results: k_{eff} (spline) vs k_{eff} (PBM) for butene

Land Use = Forest

> 500,000 points

k_{eff} [min^{-1}] from Spline Fit



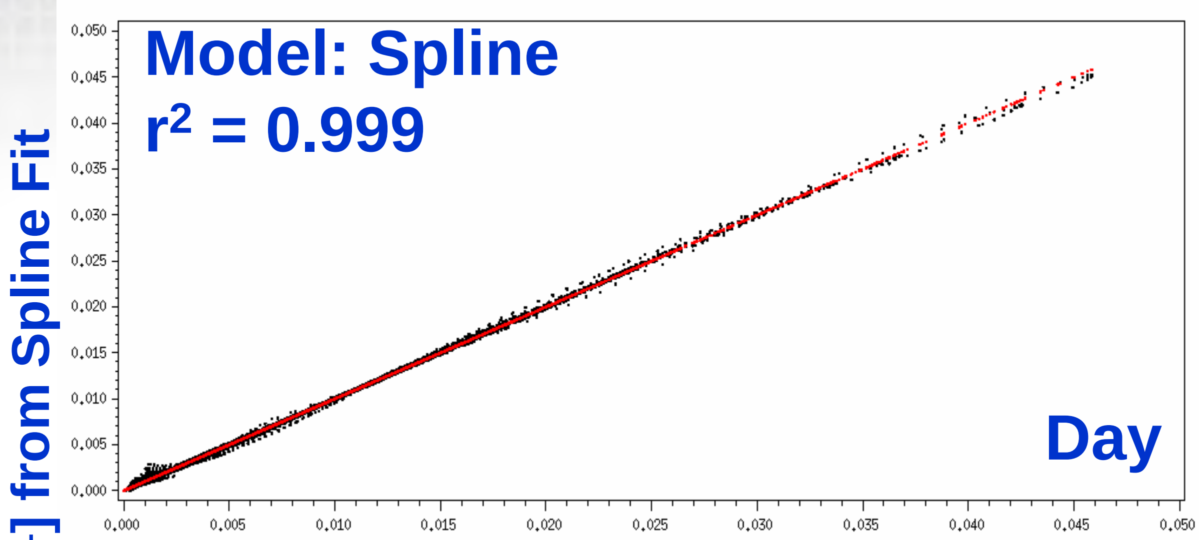


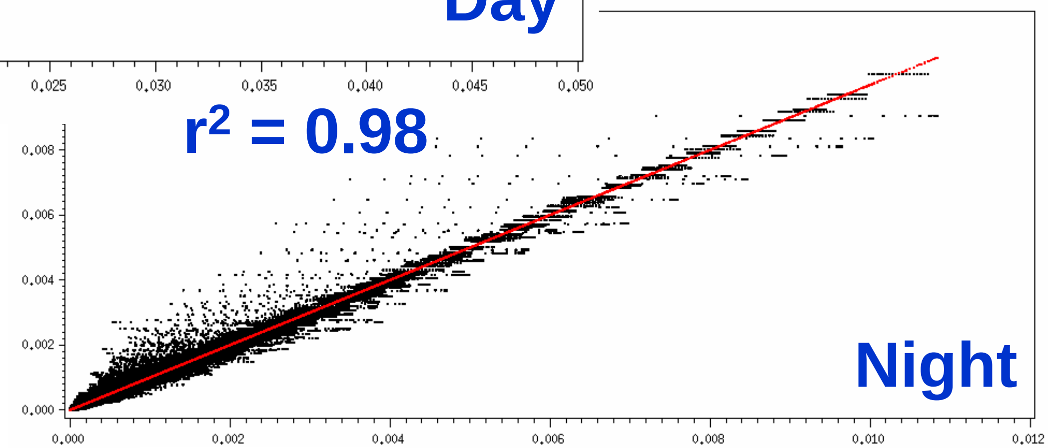
k_{eff} [min^{-1}] from PBM

Results: k_{eff} (spline) vs k_{eff} (PBM) for butene

Land Use = Urban

> 500,000 points





Summary: Improved Regression

- Phase I: 7 – 10 parameter polynomial
- Phase II: Spline Fit

Comparison & Summary of r^2 values

Land Use	Day (SE > °5)		Night (SE < °5)	
	Phase I	Phase II	Phase I	Phase II
Water	0.97	0.999	NA*	0.99
Urban	0.80	0.999	NA	0.98
Grass	0.98	0.999	NA	0.999
Forest	0.77	0.98	NA	0.99
Desert	0.83	0.99	NA	0.99
Default	0.68	0.99	NA	0.99

* Phase I k_{eff}(night) was set to a constant.

Results: Nine Alkenes

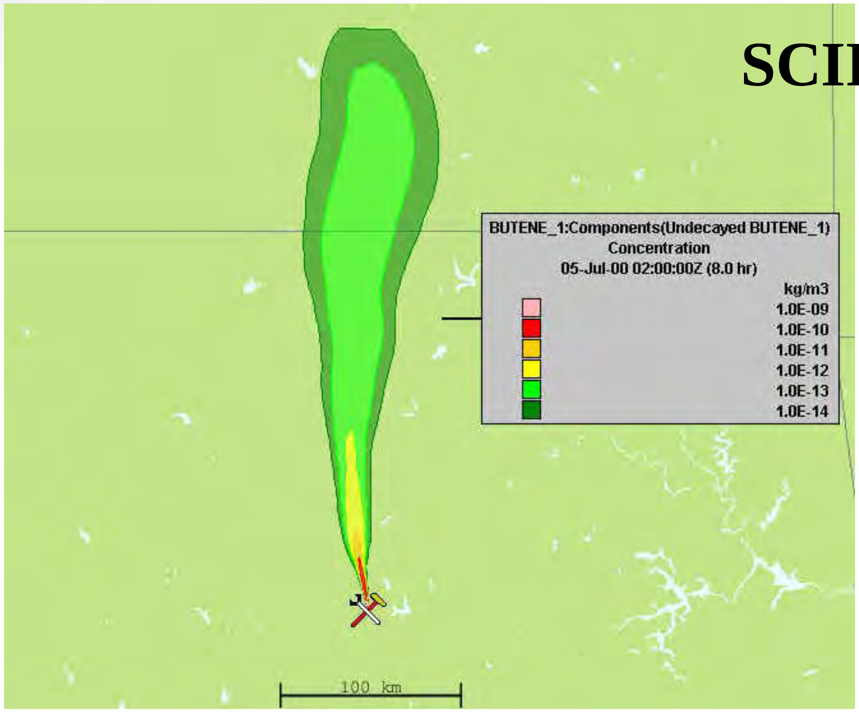
- **Priority I**
  - **1-Butene**
    - Products (**Propanal**, Nitroxybutanone).
  - Ethene
  - Propene
  - **Methylpropene**
  - 1,3-Butadiene
- **Priority II**
  - Styrene
- **Priority III**
  - cis-2-Butene
  - trans-2-Butene
  - Isoprene

Why Chemistry is Important in AT&D Modeling

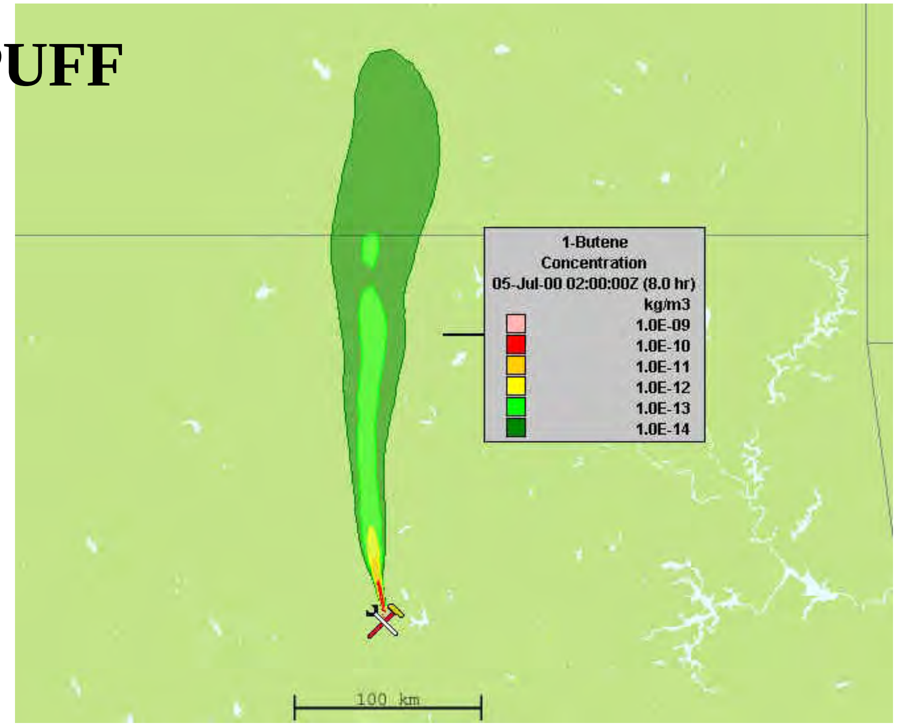
Results: T&D Compared to T&D + Chemistry (Butene)

T&D Only | T&D + Chemistry

SCIPUFF



Tracer

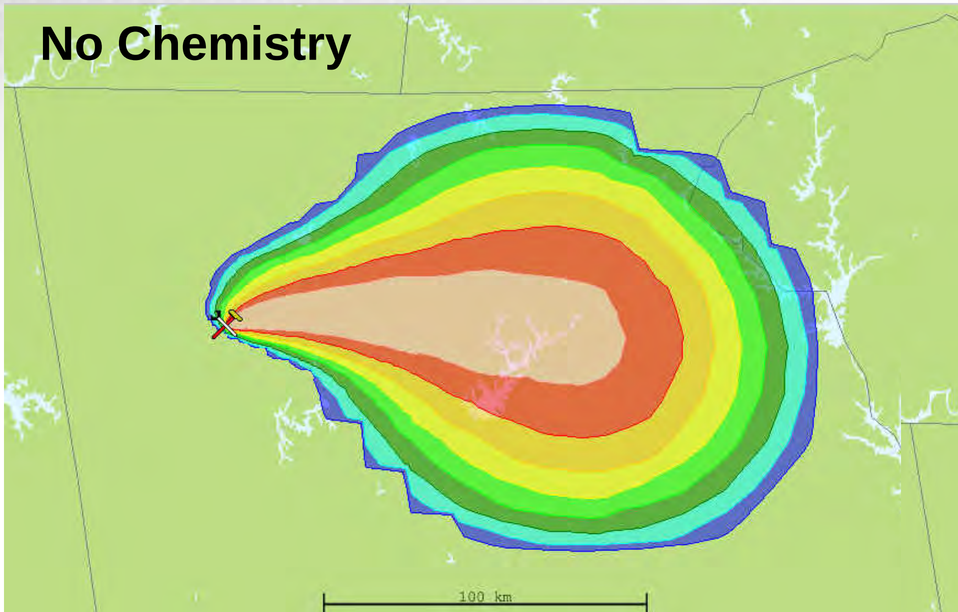


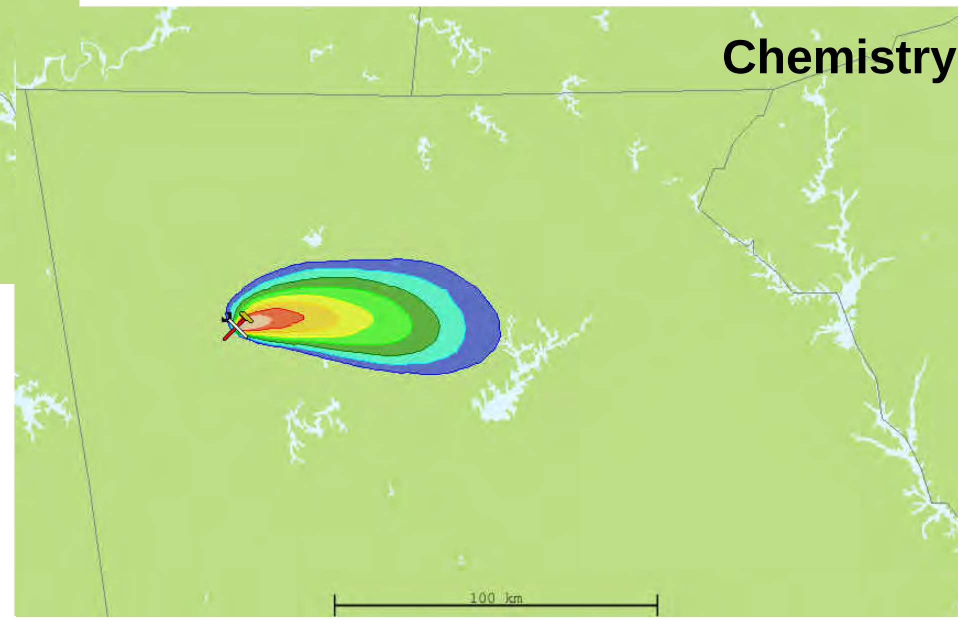
1-Butene

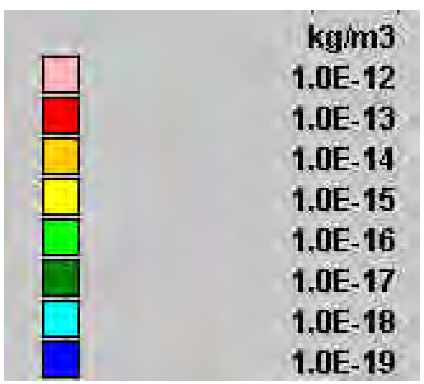
Results: Methylpropene

8 hr continuous release starting at 8 am local time

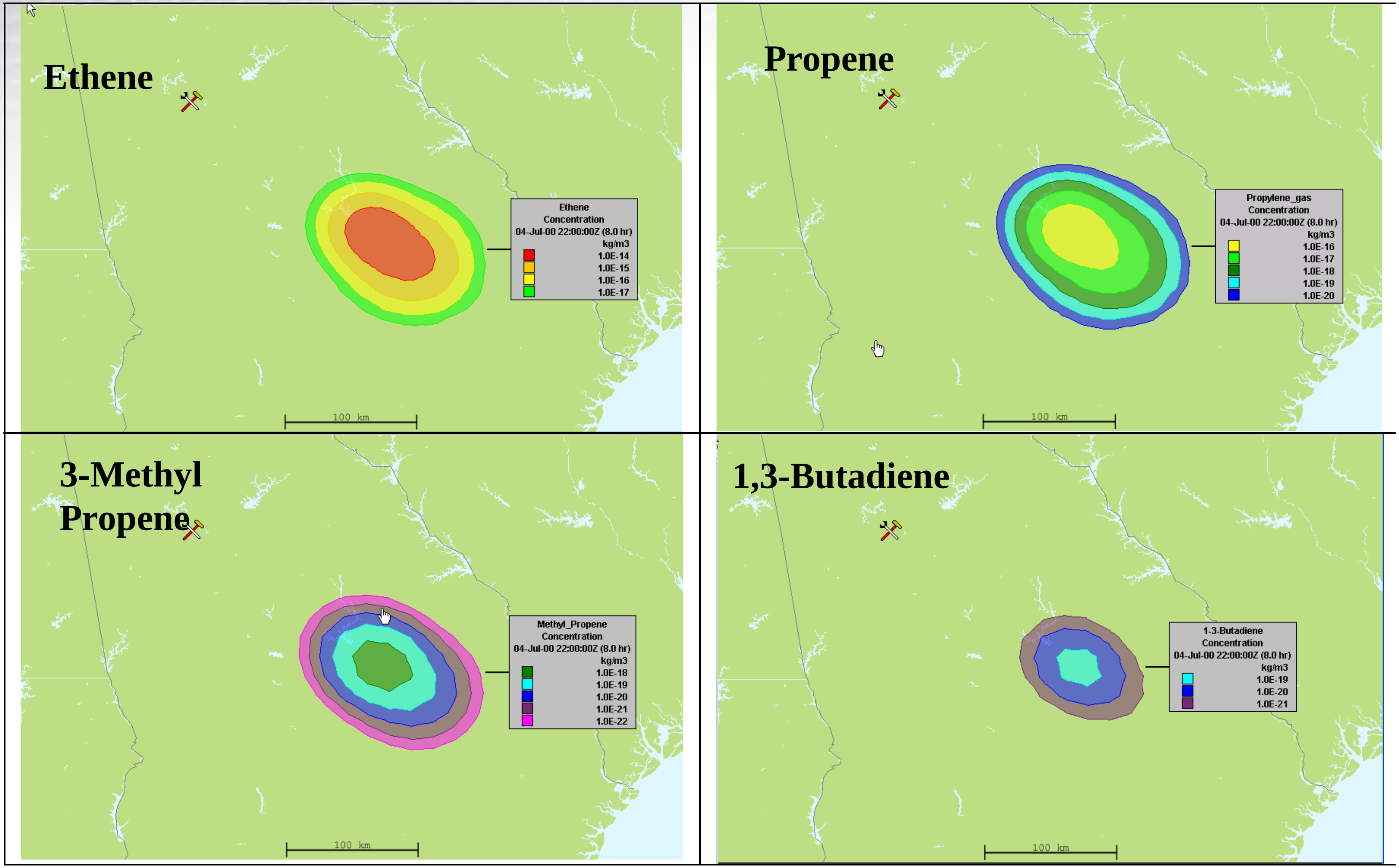
3 PM Local Time





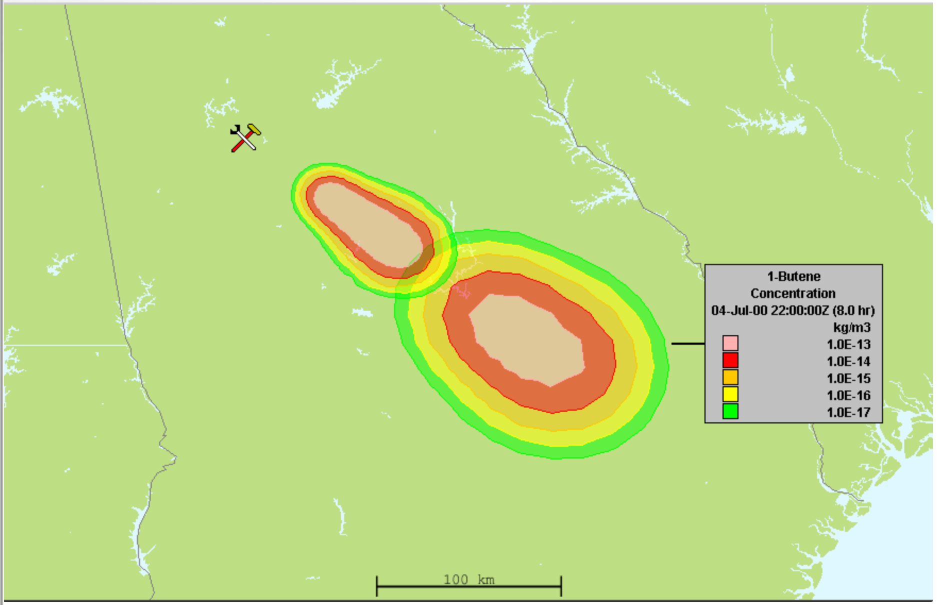


Results: Calculated Plume is TIC Dependent

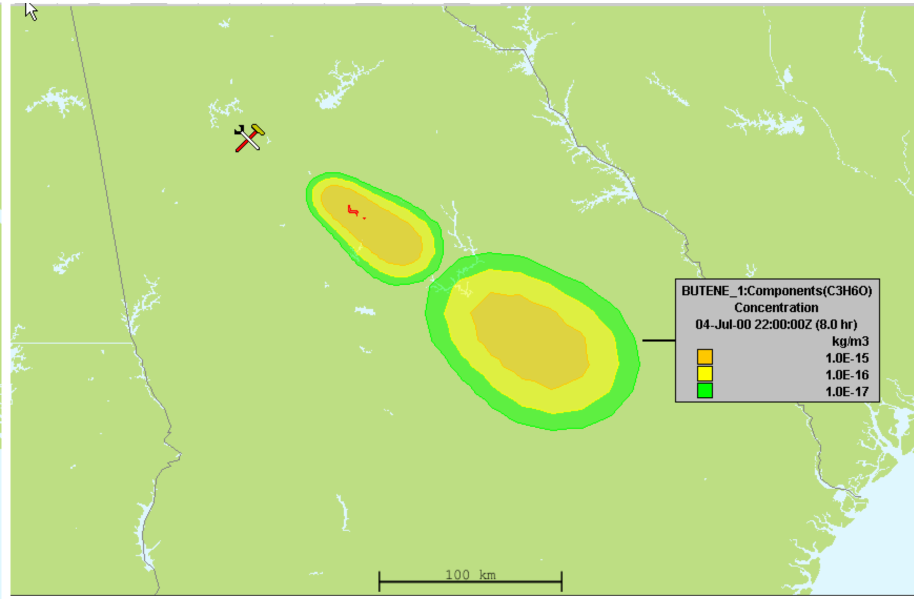


Results: TIC Decay and Product Formation

1-Butene



Propanal



At 4 hrs and 8 hrs after release

2 hr continuous release starting at noon local time

Summary & Future Work

- Phase I model
  - ***No slow down*** in SCIPUFF
  - Ability to model product formation
- Phase II Model Improved daytime k_{eff}
  - $R^2 \rightarrow$ 0.98 to 0.999 for the various land uses
- Phase II Model Significantly improved nighttime k_{eff}
  - No longer an assumed constant value
- Future Work
  - Complete testing of spline model in SCIPUFF / HPAC
    - Verify no slow down in SCIPUFF
    - Develop spline models for balance of TICs
  - Continue Sensitivity Analysis studies
  - Develop k_{eff}'s for other priority TICs
  - Chamber Expt's being Designed (Chemistry Validation)

End of slides

A Fast-Running, High Quality, Transport and Dispersion System for Urban Areas

Presented at the
Chemical Biological Information Systems Conference
January 8–11, 2007 Austin, TX

Dr. Donald A. Burrows and Steve R. Diehl
ITT Industries, Advanced Engineering and Sciences
Colorado Springs, Colorado
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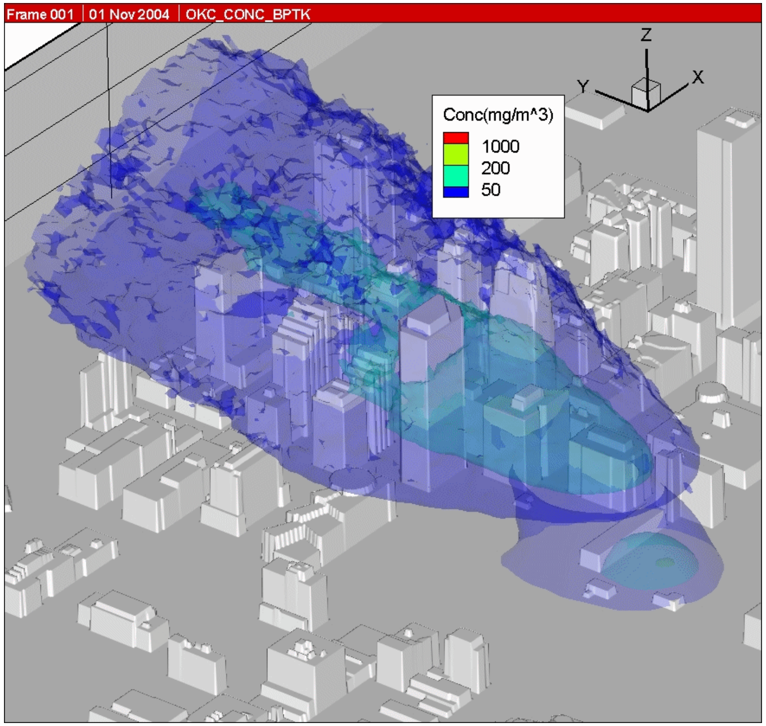
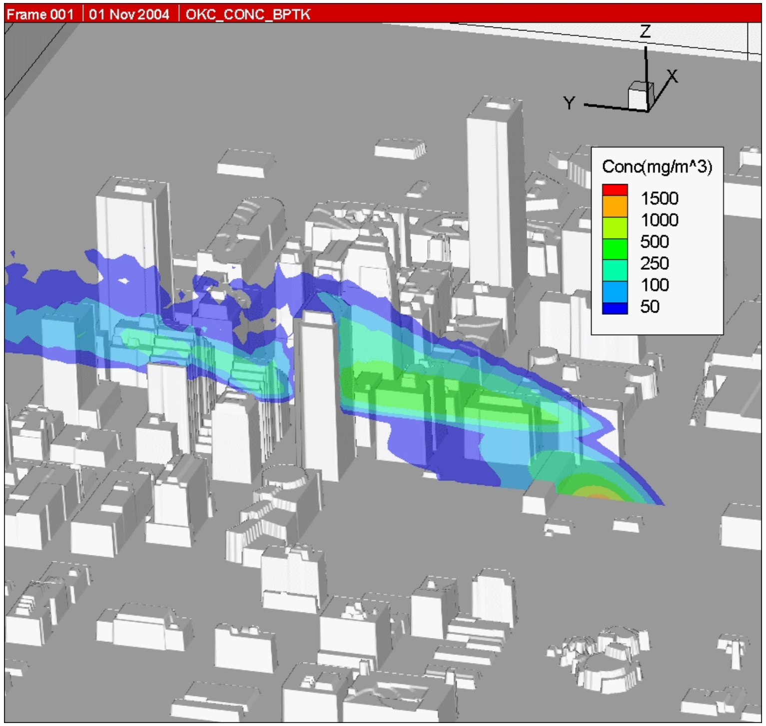
MESO/RUSTIC Outline

1. MESO/RUSTIC Urban Dispersion and Wind Flow Background
2. Comparison to Oklahoma City Data
3. RUSTIC Upgrades for FY06 JSTO Tech Base Effort





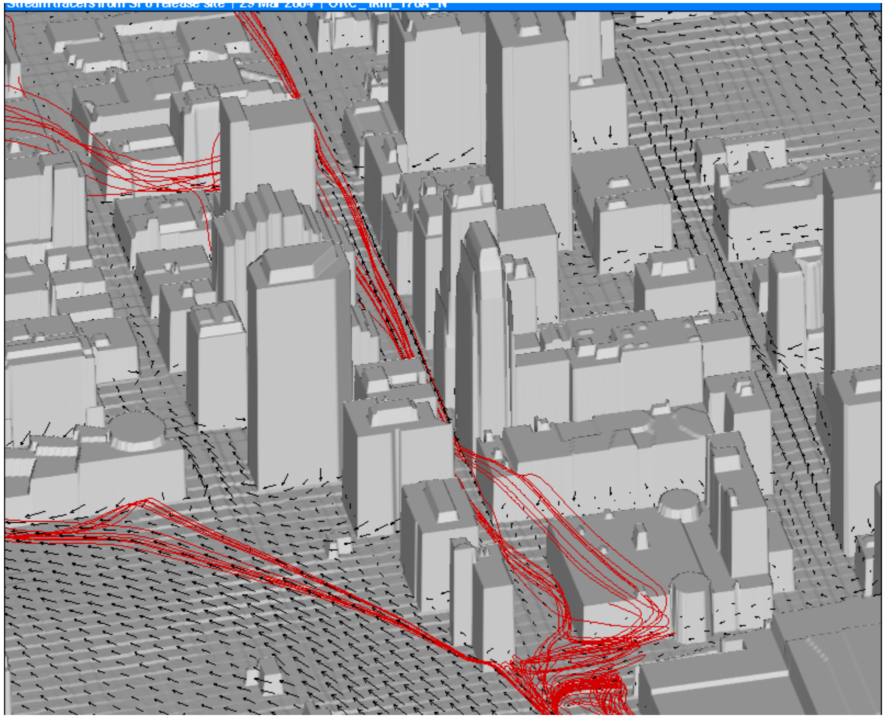
Simulated concentration levels for volatile drops release in Oklahoma City

MESO/RUSTIC is a New Generation Model That Provides Accurate 3D Urban Hazard Definitions

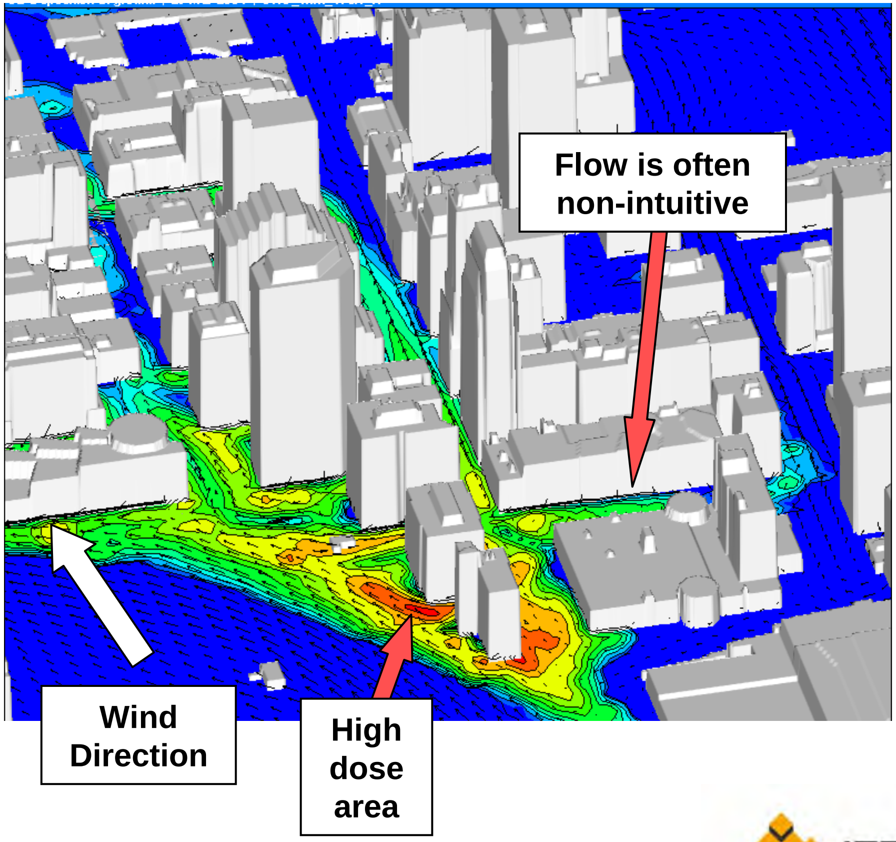
Two Steps for Urban CBR Hazard Definition with MESO/RUSTIC

1. **Compute turbulent "wind flow" with RUSTIC for urban scenarios.**

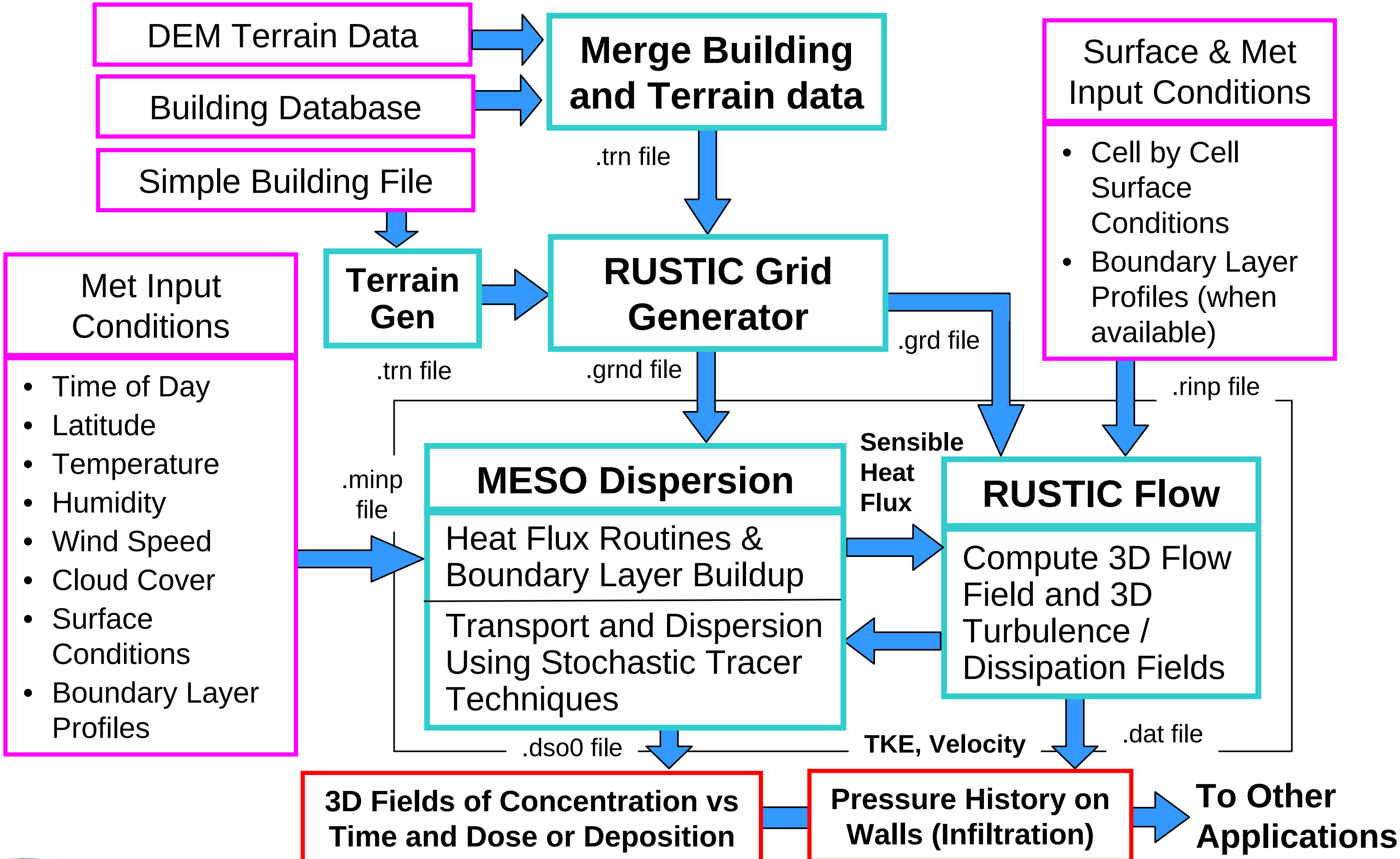
Downtown Oklahoma City July 2003



2. **Use MESO to compute contaminant dispersion with flow and turbulence predicted by RUSTIC.**

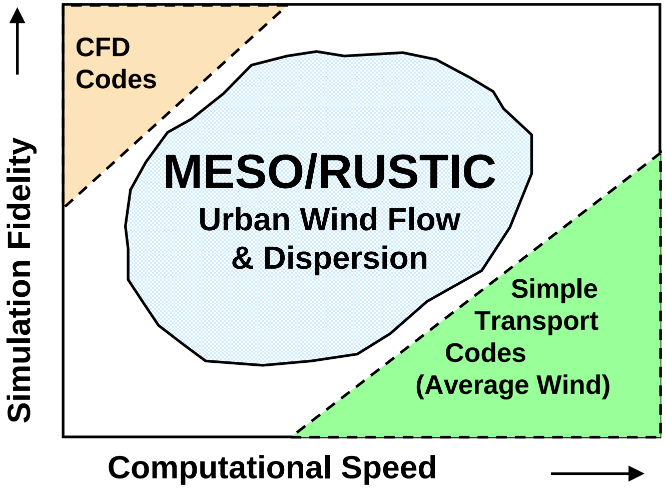


MESO / RUSTIC Urban Transport & Dispersion Data Flow



RUSTIC - A Fast-Running Urban Airflow Model

- RUSTIC is a model that solves the equations of motion and includes a k-ω turbulence model as well as heat flux and stability effects.
- It's simplified implementation allows it to run in a reasonable time on an ordinary PC with only a single processor.



- For the most accurate solutions, run times for ~1 km square urban areas with 5 meter minimum grid cell size may require 8 - 24 hours (single PC).
- For quick "good-enough" solutions using the multi-grid technique run times can be reduced to the 0.5 - 1 hour range.
- Proposed CY07 ITT IR&D project will enhance MESO/RUSTIC speed.

RUSTIC: A Fast-Running Urban Airflow Model

Momentum Equation

$$\frac{\partial \vec{u}}{\partial t} + \vec{u} \cdot \nabla \vec{u} = -\frac{1}{\rho} \nabla P - \vec{g} + \frac{1}{\rho} \left(\nabla \cdot \rho K_m \nabla \right) \vec{u}$$

$$K_m = \frac{k}{\omega}$$

k = Turbulence Kinetic Energy

ω = Dissipation Coefficient

k- ω Turbulence Equations

$$\frac{\partial k}{\partial t} = -u_j \frac{\partial k}{\partial x_j} + \tau_{ij} \frac{\partial u_i}{\partial x_j} - \beta^* k\omega + \frac{\partial}{\partial x_j} \left[\left(\nu + \sigma^* \frac{k}{\omega} \right) \frac{\partial k}{\partial x_j} \right]$$

$$\frac{\partial \omega}{\partial t} = -u_j \frac{\partial \omega}{\partial x_j} + \alpha \frac{\omega}{k} \tau_{ij} \frac{\partial u_i}{\partial x_j} - \beta \omega^2 + \frac{\partial}{\partial x_j} \left[\left(\nu + \sigma \frac{k}{\omega} \right) \frac{\partial \omega}{\partial x_j} \right]$$

$$\tau_{ij} = \frac{k}{\omega} \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right) - \frac{2}{3} \delta_{ij}$$

RUSTIC: A Fast-Running Urban Airflow Model

Pressure Equation

Mass Continuity Equation

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \rho \vec{U} = 0$$

+

Thermodynamic Equation

(no heat sources or sinks)

$$\frac{\partial \theta}{\partial t} + \vec{U} \cdot \nabla \theta = \frac{1}{\rho} \left(\nabla \bullet \rho K_H \nabla \right) \theta$$

Results in Pressure Tendency Equation

$$\frac{\partial P'}{\partial t} = -\vec{U} \cdot \nabla P + w \bar{\rho} g - \bar{\rho} c^2 \left(\nabla \cdot \vec{U} - \frac{1}{\bar{\rho} \theta} \left(\nabla \bullet \bar{\rho} K_H \nabla \right) \theta \right)$$

Speed of Sound

Note: $\rho = \rho' + \bar{\rho}(z)$

And for this model $\rho' \equiv 0$

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RUSTIC Grid Generation Procedure

Bird's eye view of urban area building

Actual Photograph

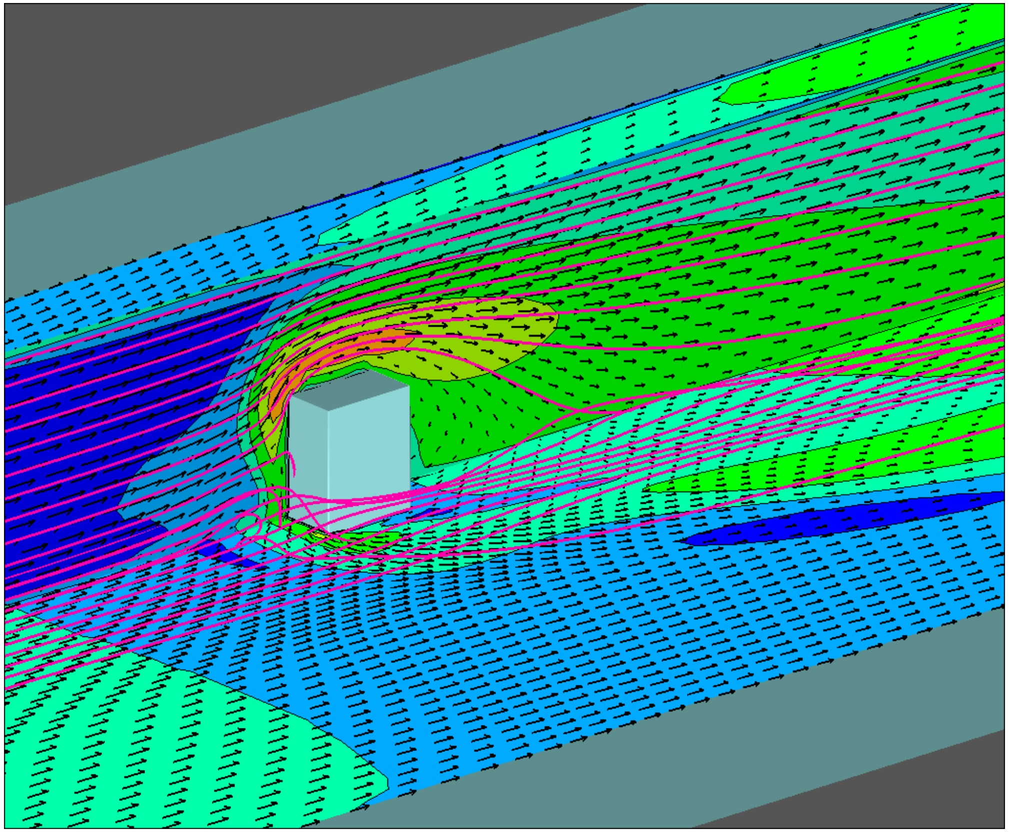
Automated RUSTIC

- Starting with terrain data as a DEM file the buildings are added
- Initial building data is in form of ESRI shape files containing a footprint outline with a roof height
- The footprints are sorted by roof top height to be processed one at a time from lowest to highest
- DEM file, 2-D array of elevations at 1 m resolution aligned with wind direction, is created for the city
- Finally the city DEM file is merged with model grid volume
- RUSTIC accepts eight (8) different terrain formats.

.

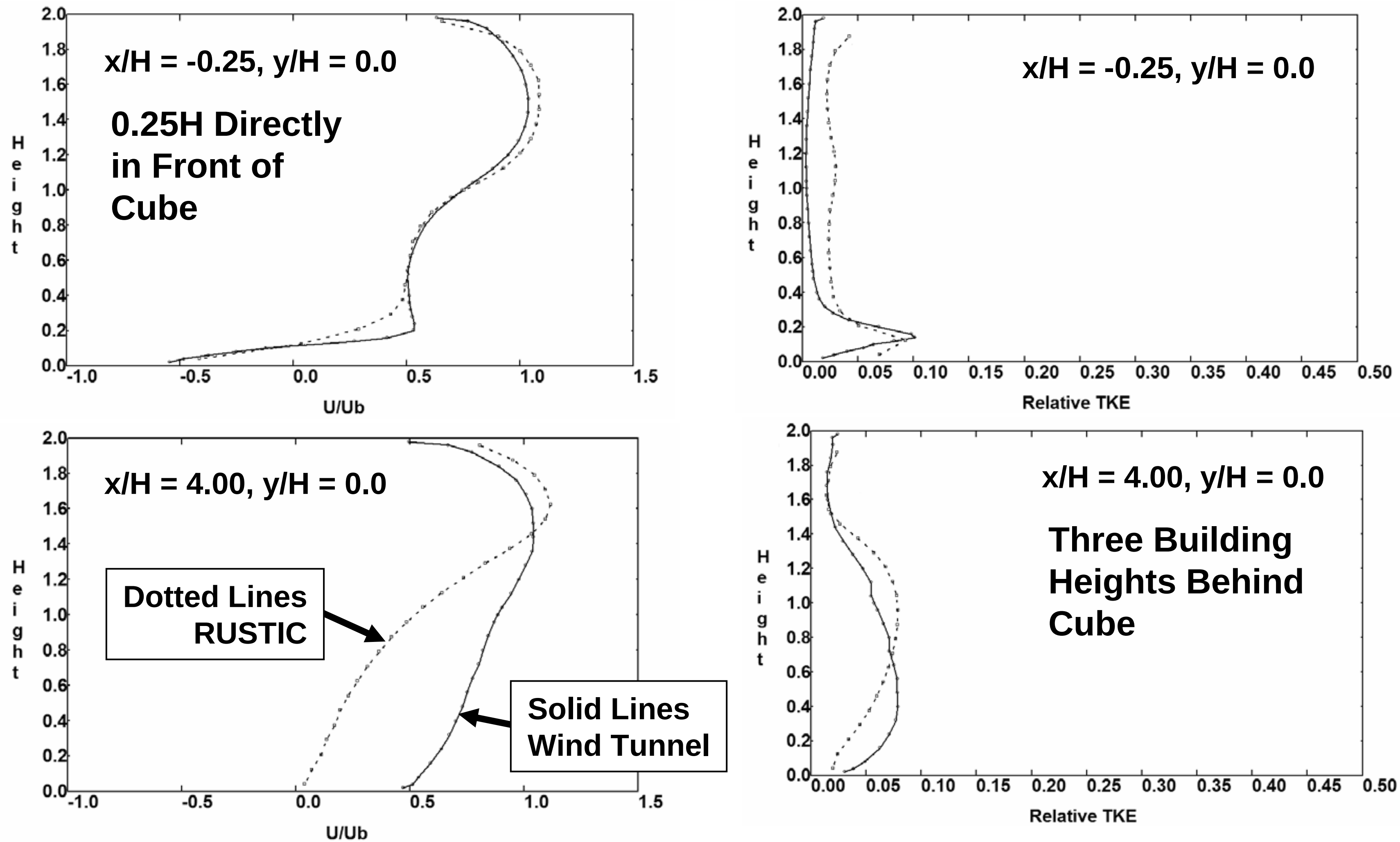
RUSTIC Validation Studies

- Comparison with wind tunnel measurements of flow around a cube in a channel (Martinuzzi and Tropea, 1993)
- Measurements were made of u,v,w velocity components and TKE
- RUSTIC simulation run to convergence using three different resolutions
- A simulation was also run for this scenario using a CFD model, ADVEDS_NS



Streamlines and wind vectors from RUSTIC simulation of flow around a cube in a channel. Contours are of TKE.

RUSTIC Comparisons with Martinuzzi and Tropea (1993) "Cube in a Channel" Wind Tunnel Data



H is building height, x/H=0.0 is upwind face of building and x/H=1.0 is downwind face of building, U is wind velocity, Ub is mean wind velocity and TKE is Turbulent Kinetic Energy.

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MESO Random-Walk Excursion Techniques for Accurate Dispersion

Random-Walk Tracer Techniques

- First-Principles Physics
- Not Based on Gaussian Puffs
- No Grid or Numerical Instabilities
- Excellent Spatial Resolution
- Accurate Advection in Complex Terrain
- Rapid Execution

3D Time-Dependent Wind Fields Over Rough Terrain

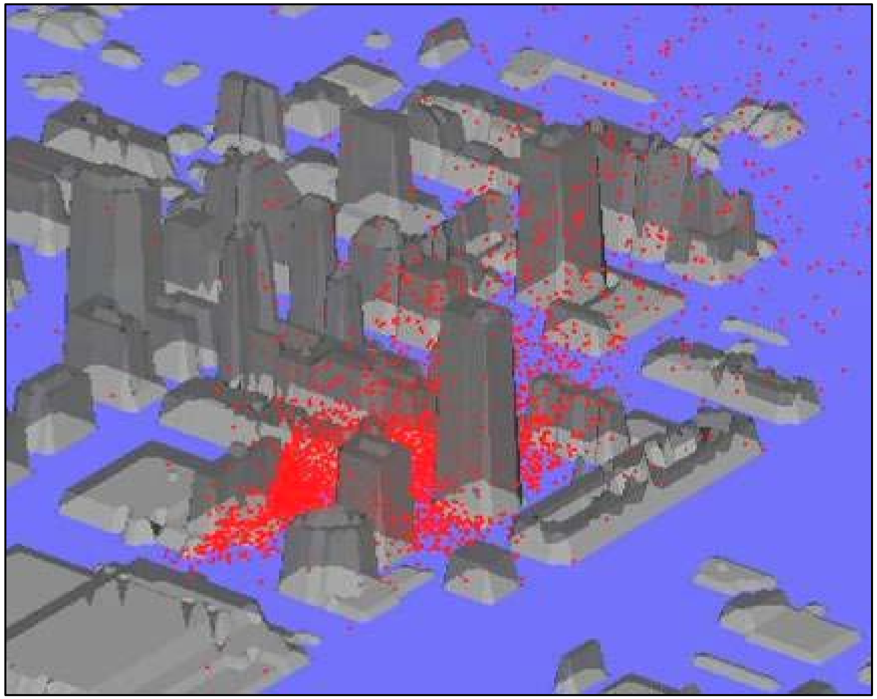
Spatially-Varying Surface Characteristics

State-of-the-Art Meteorology

Full Chem/Bio Capabilities

Dose/Deposition Variance

Urban Dispersion Capability



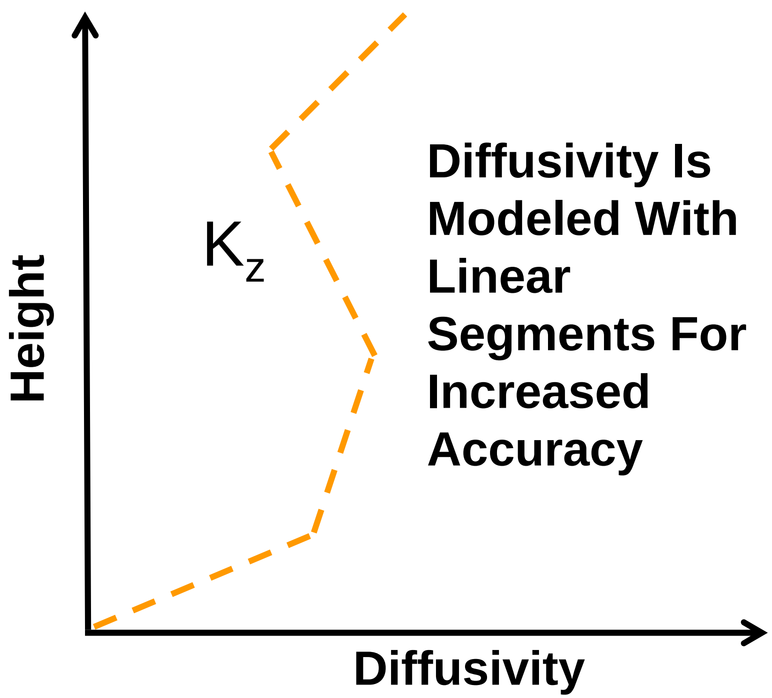
MESO/RUSTIC handles urban and rural cases

MESO Uses Random-Walk Tracer Techniques For Urban Dispersion

<u>Random-Walk Technique</u>: Diehl, et al. 1982, J. Applied Met., 21, 69-83.

- Rigorously meets well-mixed condition (i.e. no artificial drift)
- Numerically fast (single random bit per displacement)
- No grid required; good spatial resolution (1 to 4 m typical)
- Diffusivity is reduced for droplet inertia

Diffusivity: 3D Time-Dependent Turbulence Fields From RUSTIC



Scale-Dependent Dispersion

For Instantaneous Releases, i.e. Clouds, Scale-Dependent Techniques Are Required:

- Only turbulence scales smaller than cloud are included in the dispersion.
- Horizontal: Cloud divided into layers
- Vertical: Whole cloud

Unclassified

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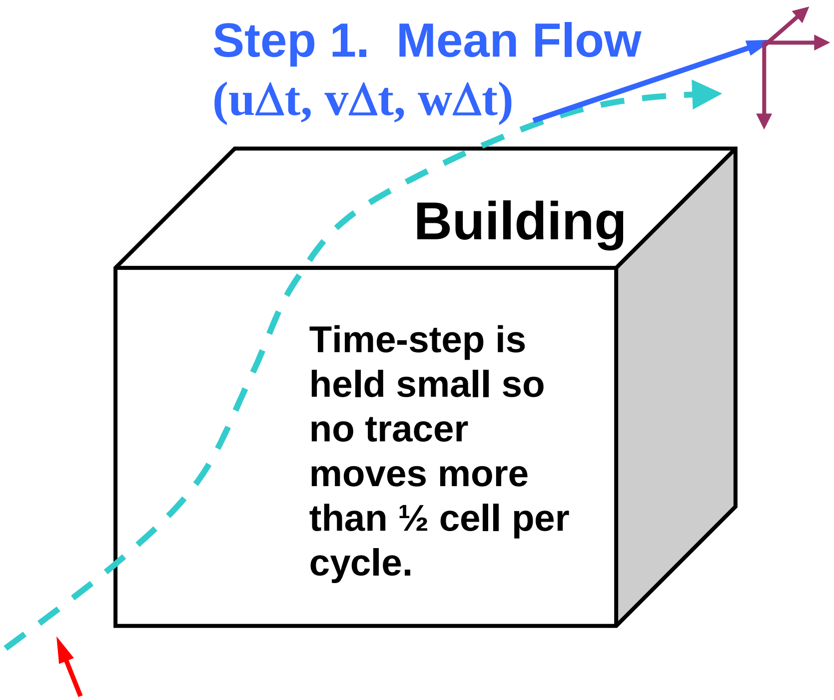
MESO Numerical Techniques: Turbulent Flow

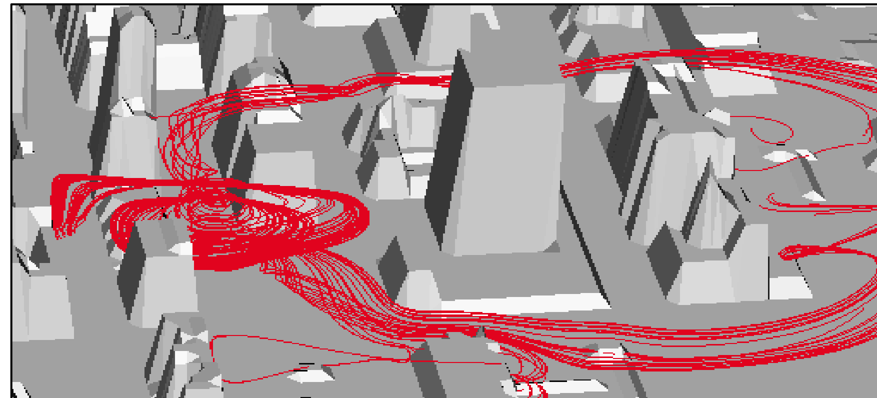
MESO moves tracers with the mean flow and uses a random-walk process to represent the turbulent motion.

Step 2. 3D Random Walk For Turbulent Mixing

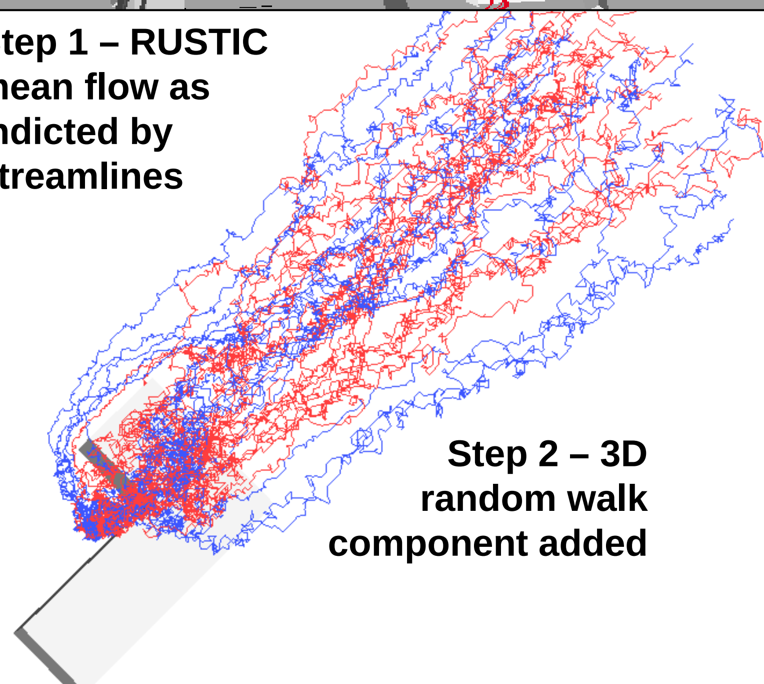
Step 1. Mean Flow
$(u\Delta t, v\Delta t, w\Delta t)$



Mean Flow Predicted By RUSTIC



Step 1 – RUSTIC mean flow as indicted by streamlines



Step 2 – 3D random walk component added

MESO Capabilities Used for Accurate Transport and Dispersion

Heat Flux Models

State-of-the-Art Using Numerical Iteration Based On:
- Long and Short Radiation
- Cloud Cover (3 altitudes)
- Albedo vs Angle
- Wind Speed
- Surface Roughness
- Humidity
- **Surface Evaporation Resistance**
- Vegetation Thickness
- Validated with FIFE field data

Planetary Boundary Layer Model

Numerically Integrated Ahead in Time Based On:
- Sensible Heat Flux
- Wind Speed
- Potential Temperature Profile
- Surface Roughness z_o
- **Convective Boundary Layer Decay Model**
- **Dynamic 2nd-Order Closure CBL Model**

Turbulent Deposition

State-of-the-Art Algorithm Based on:
- Particle Size
- Wind Speed (u_*)
- Stability (L)
- Surface Roughness (z_o)
- Vegetation Characteristics (Filtration Effects)

Chemical and Biological Agents

- Droplet Size Bins
- Auto Lognormal Size Distribution
- Evaporation With Vapor Feedback (Numerical First-Principle)
- Accurate Settling Velocity
- **Diffusivity Decreases with Droplet Size (Inertial Effect)**

MESO Output

- Ground Deposition
- Dosage
- Concentration
- **Conditional Probability**

NAVSEA WARFARE CENTERS DAHLGREN

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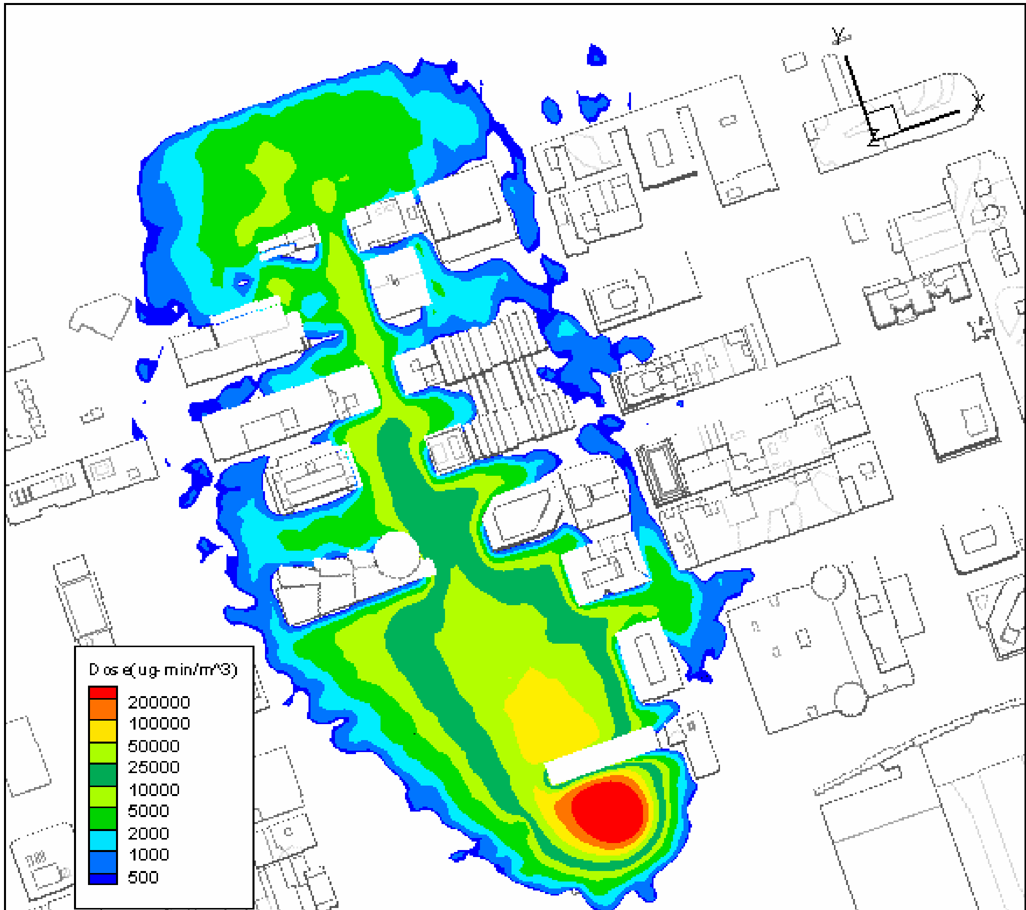
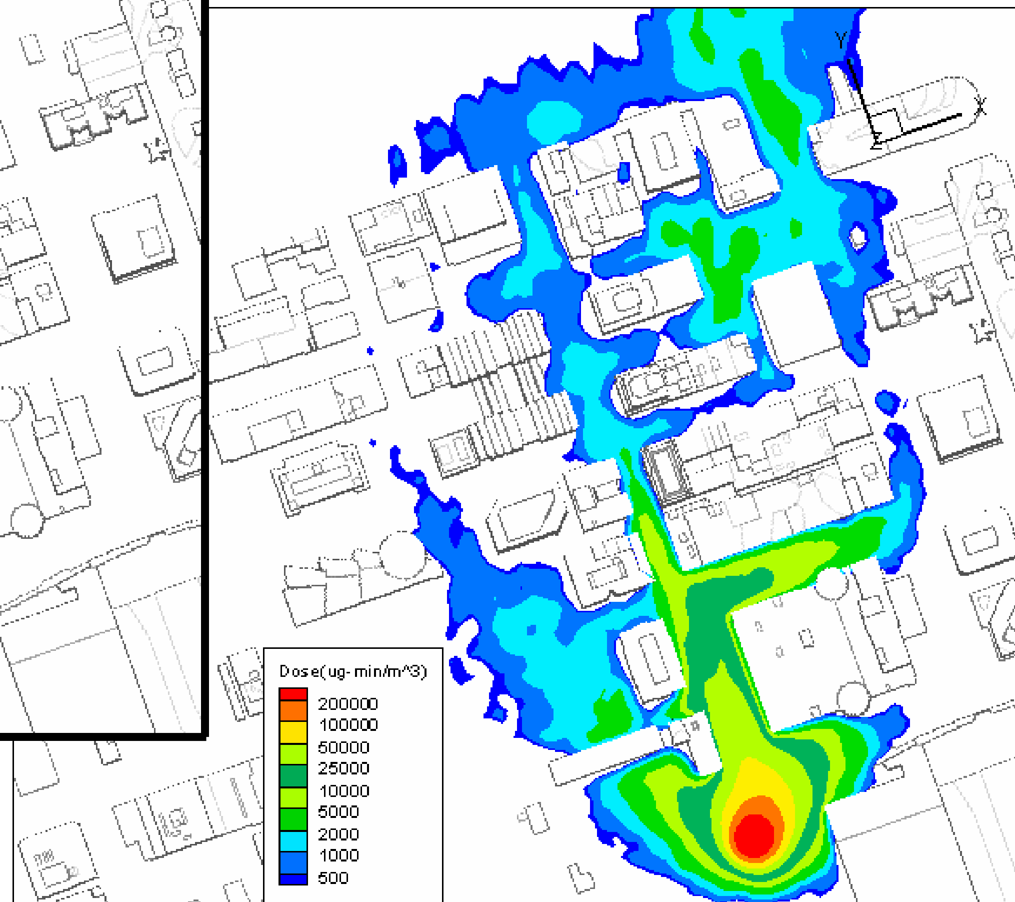
Why Higher-Fidelity Modeling is Especially Needed in the Urban Environment

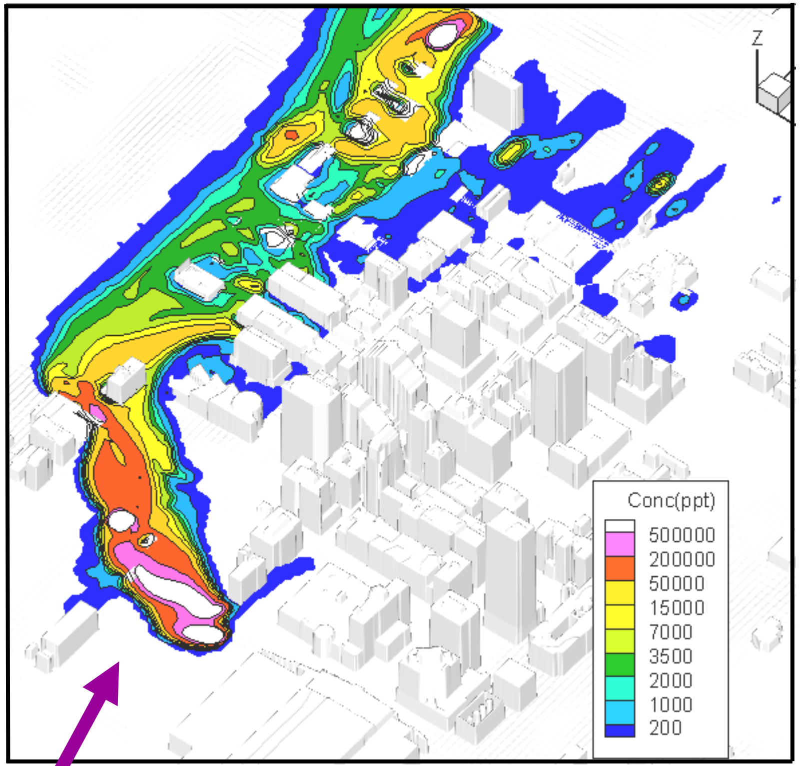


Small shift in the source location results in large shift in the hazard area.



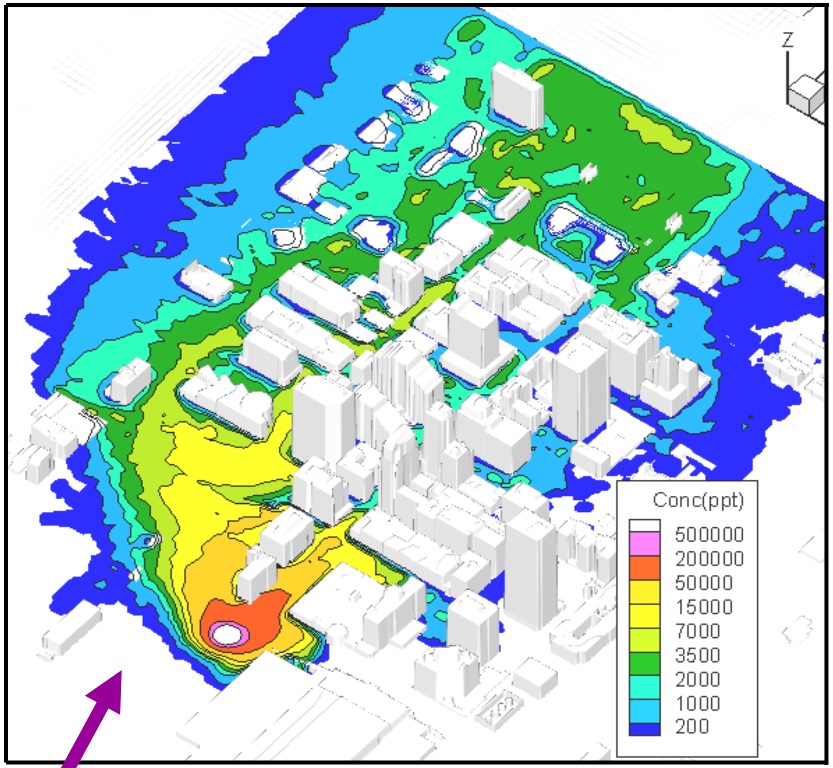
MESO / RUSTIC Simulations

Why Higher-Fidelity Modeling is Especially Needed in the Urban Environment



WD 170°

STABLE
Heat flux upwind: -30 W m^{-2}
Heat flux grid: -5 W m^{-2}

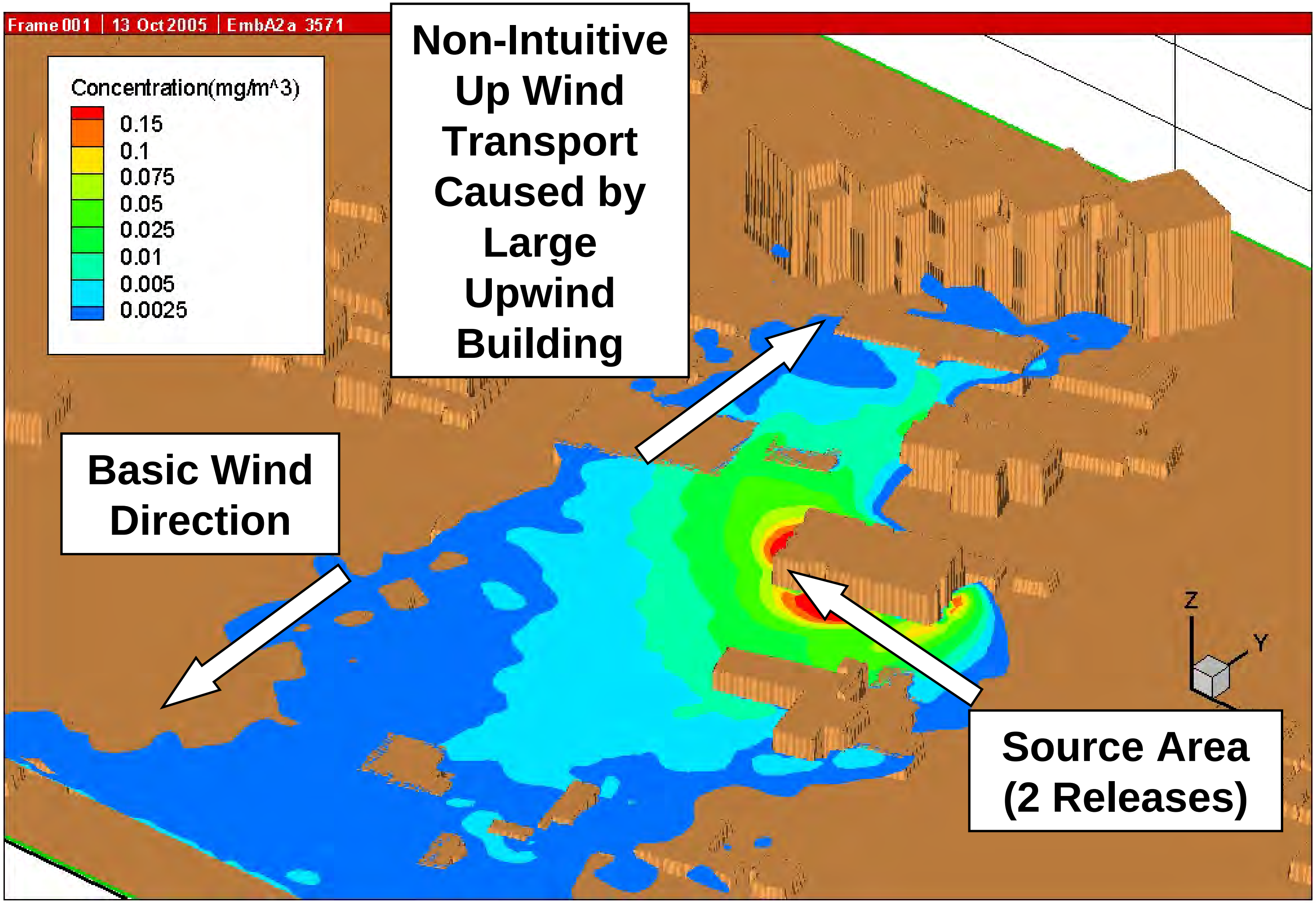


WD 170°

UNSTABLE
Heat flux upwind: 250 W m^{-2}
Heat flux grid: 50 W m^{-2}

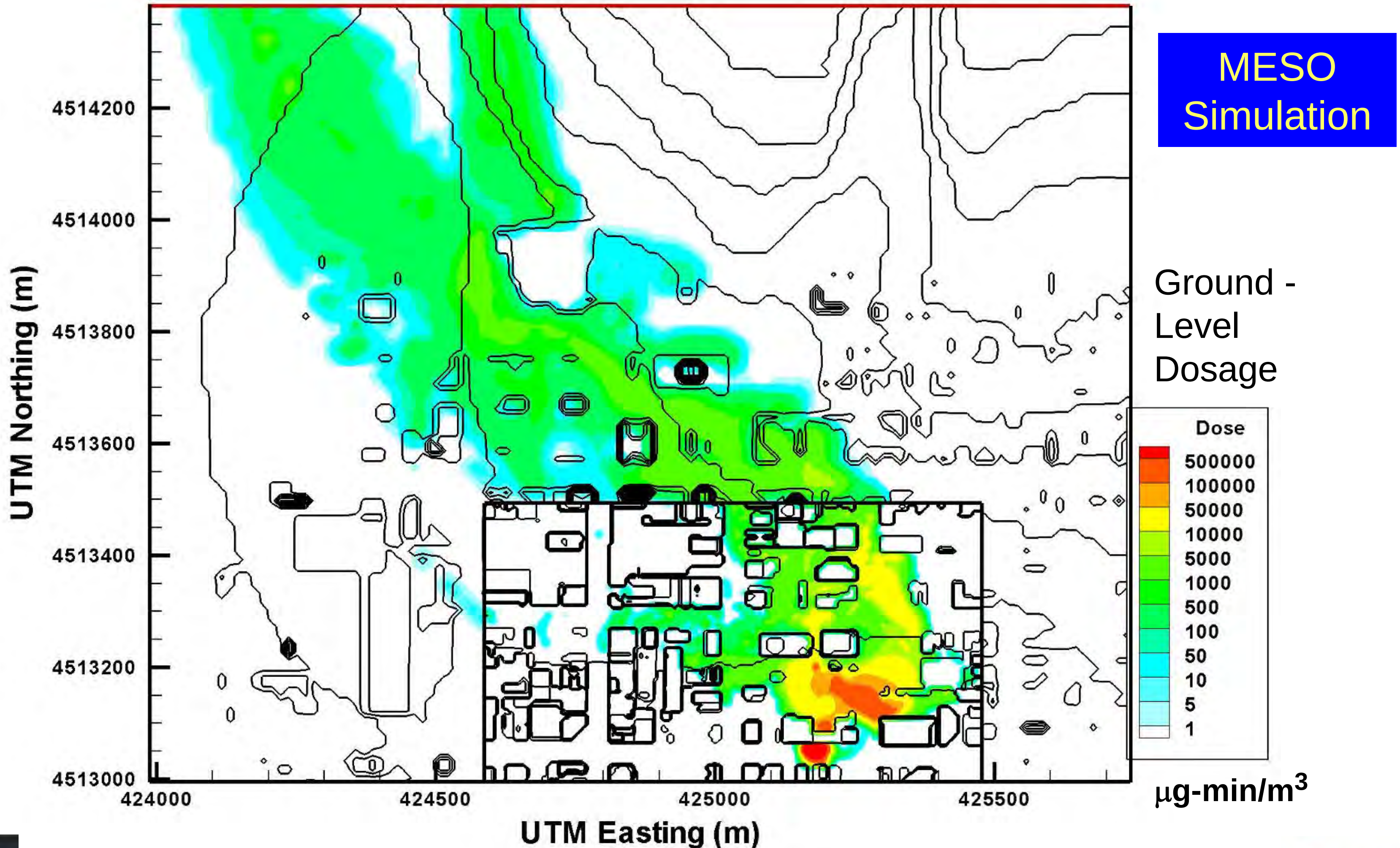
Concentration levels vary greatly for different atmospheric stabilities

Why Higher-Fidelity MESO/RUSTIC is Especially Needed in the Urban Environment



Preliminary Fine-to-Coarse Grid Simulations Give Detail Where Needed Most and Yet Remains Sensitive to Land Features

10 kg Instantaneous Release of 3 μm Particles in Salt Lake City



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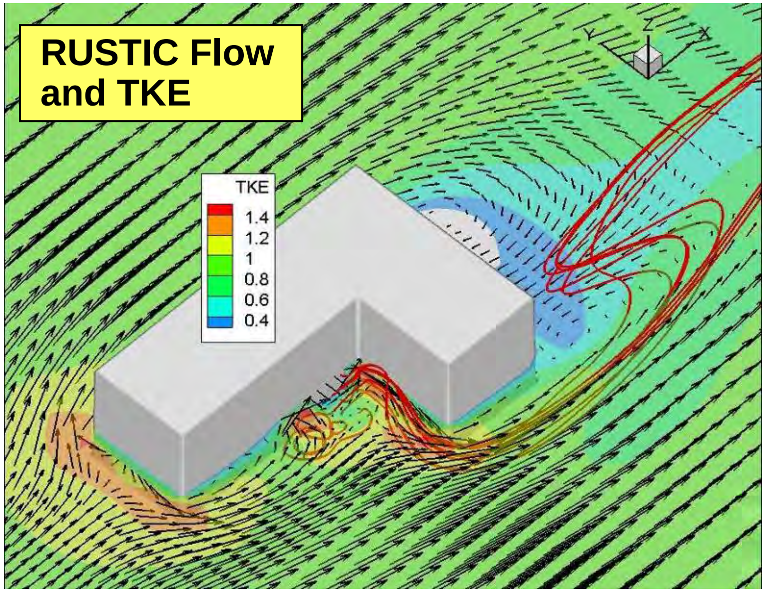
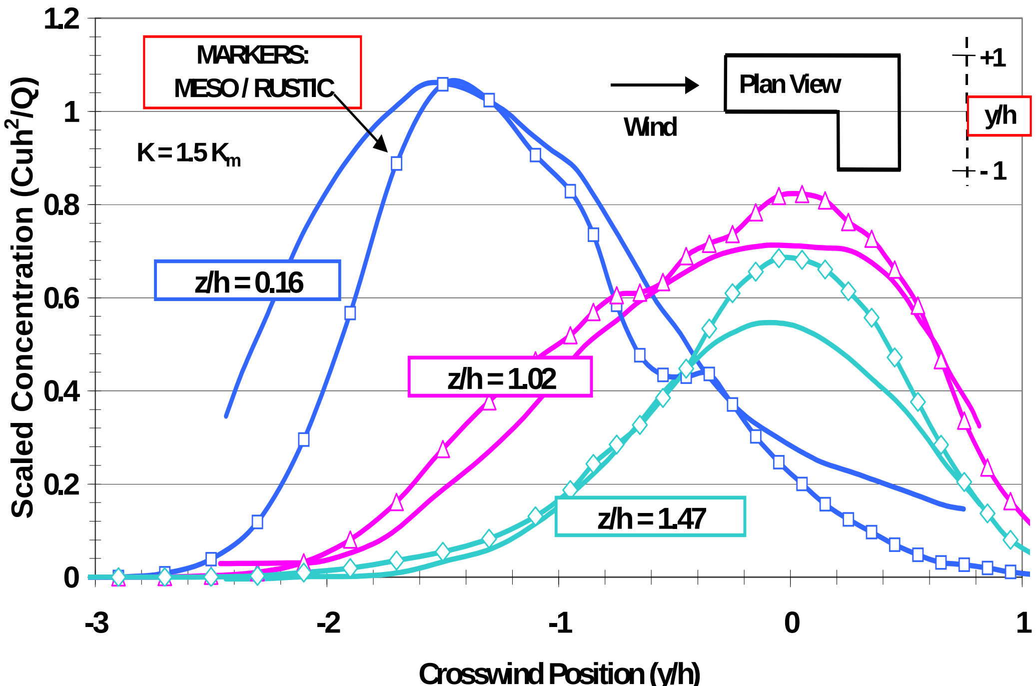
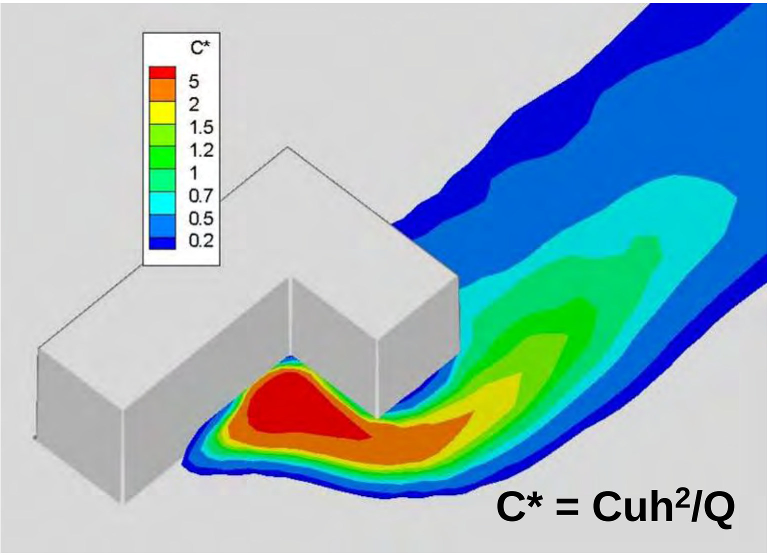
EMU Wind Tunnel Test Geometry for Case A1

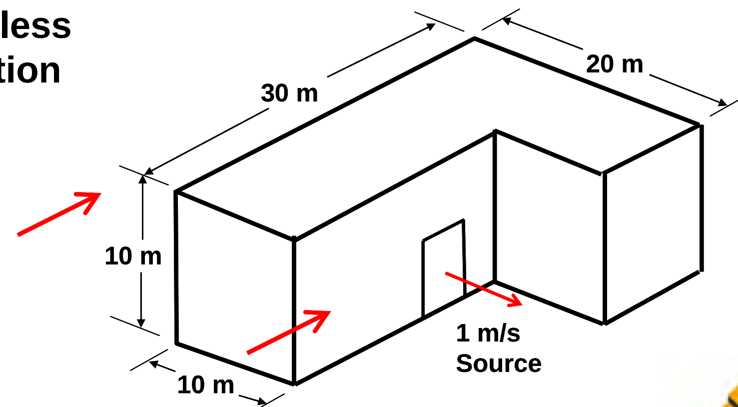
Cowan, I. R., I. P. Castro and A. G. Robins (1997 and 1999)







RUSTIC Dimensionless Concentration



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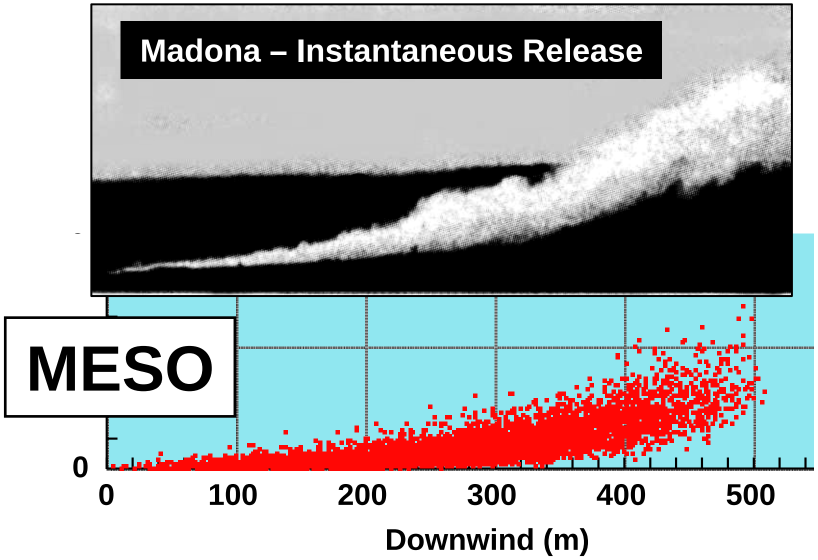
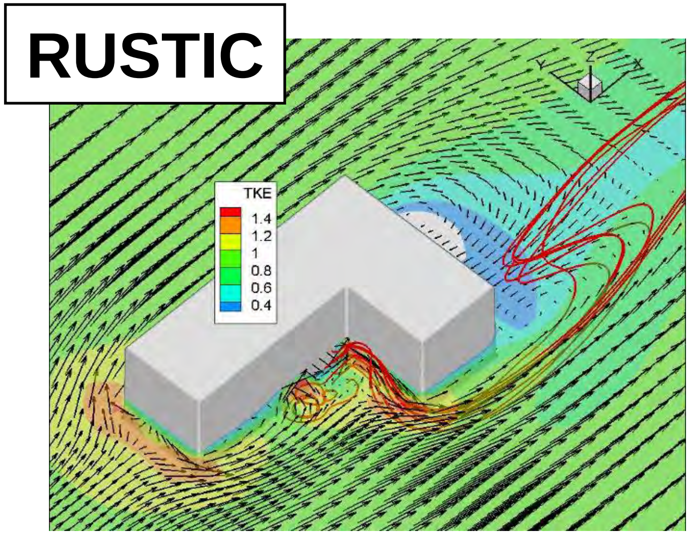
MESO and RUSTIC Validation Examples

- MADONA lidar data
- Optical cloud data
- Standard Short-Range Surface Releases
- High Stack Emissions
- Crystal Mist Test Data (High Altitude/PBL)
- Dugway Test Data (Surface Deposition)
- Pea Sooper (1.0 and 1.5 mm Beads)
- Numerous sub-model validation efforts

- Wind Tunnel Urban Testing
  - L-Shaped Building
  - Cube in a Channel
  - Parking Garage
- Joint Urban 2003 Oklahoma City Tests
  - Day and night releases
  - Instantaneous releases
  - Continuous releases



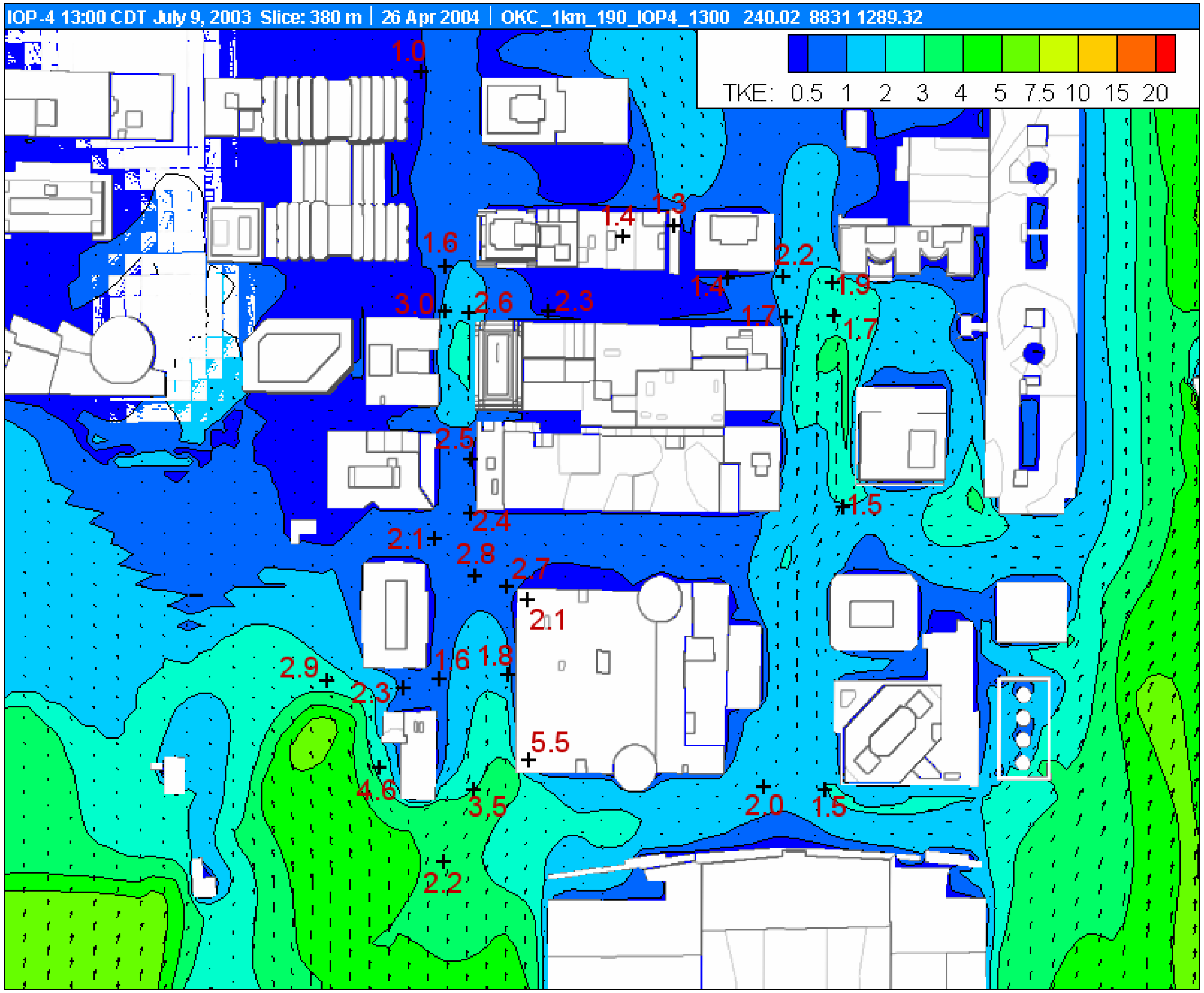


Joint Urban 2003 Field Program

- **Joint Urban 2003 Atmospheric Dispersion Study – June 28th through July 31st, 2003**
  - Ten test events with releases of SF6 and other tracers
  - Detailed wind, turbulence, tracer concentrations and other meteorological measurements during test periods
- **DARPA provided ITT support for fielding**
  - Five (5) SF6 analyzers
  - Eleven (11) 3D sonic anemometer systems
- **Instrument manufacturing and delivery**
  - SF6 sensors manufactured by ScienTech
  - ITT built data acquisition and calibration systems
  - Campbell Scientific 3D sonic anemometer systems

July 2003 urban dispersion field test was in downtown Oklahoma City

A Study of Turbulent Kinetic Energy produced by Buildings in an Urban Central Business District



- TKE contours for simulation for 13:00 - 14:00 CDT on July 9, 2003.
- Points are mean TKE measured by sonic anemometers.

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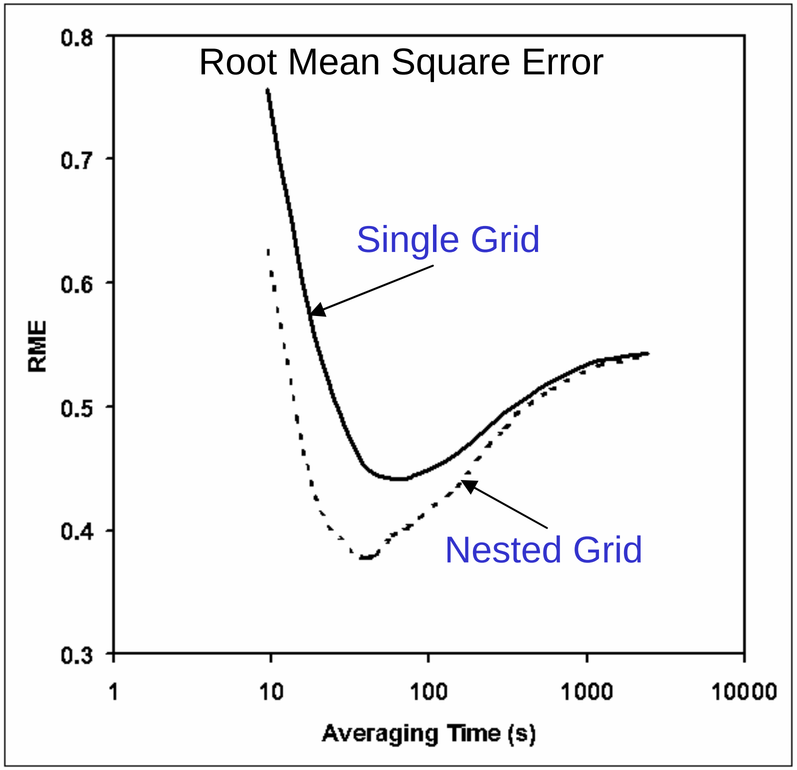
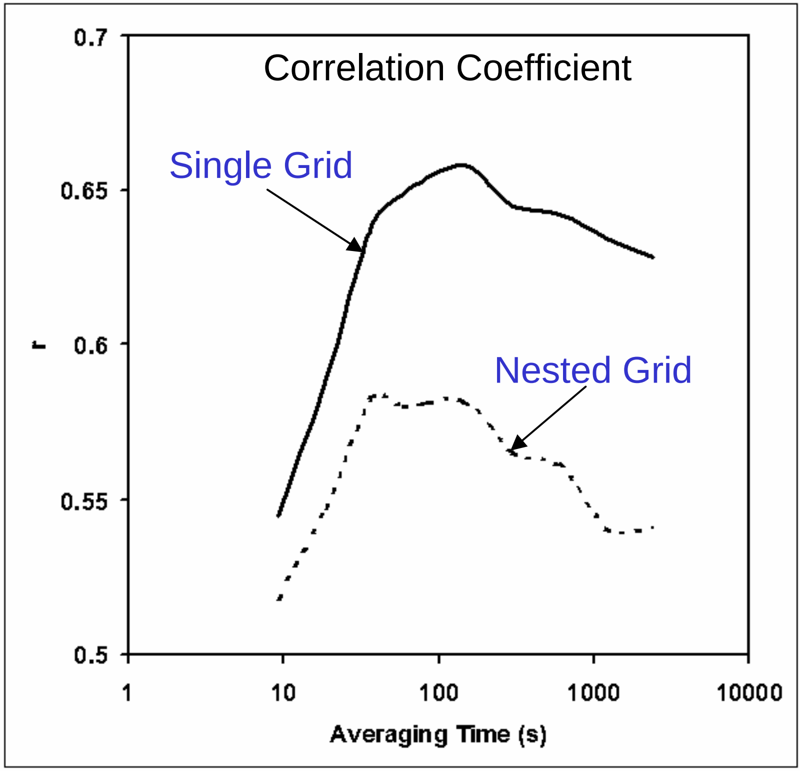
A Study of Turbulent Kinetic Energy produced by Buildings in an Urban Central Business District



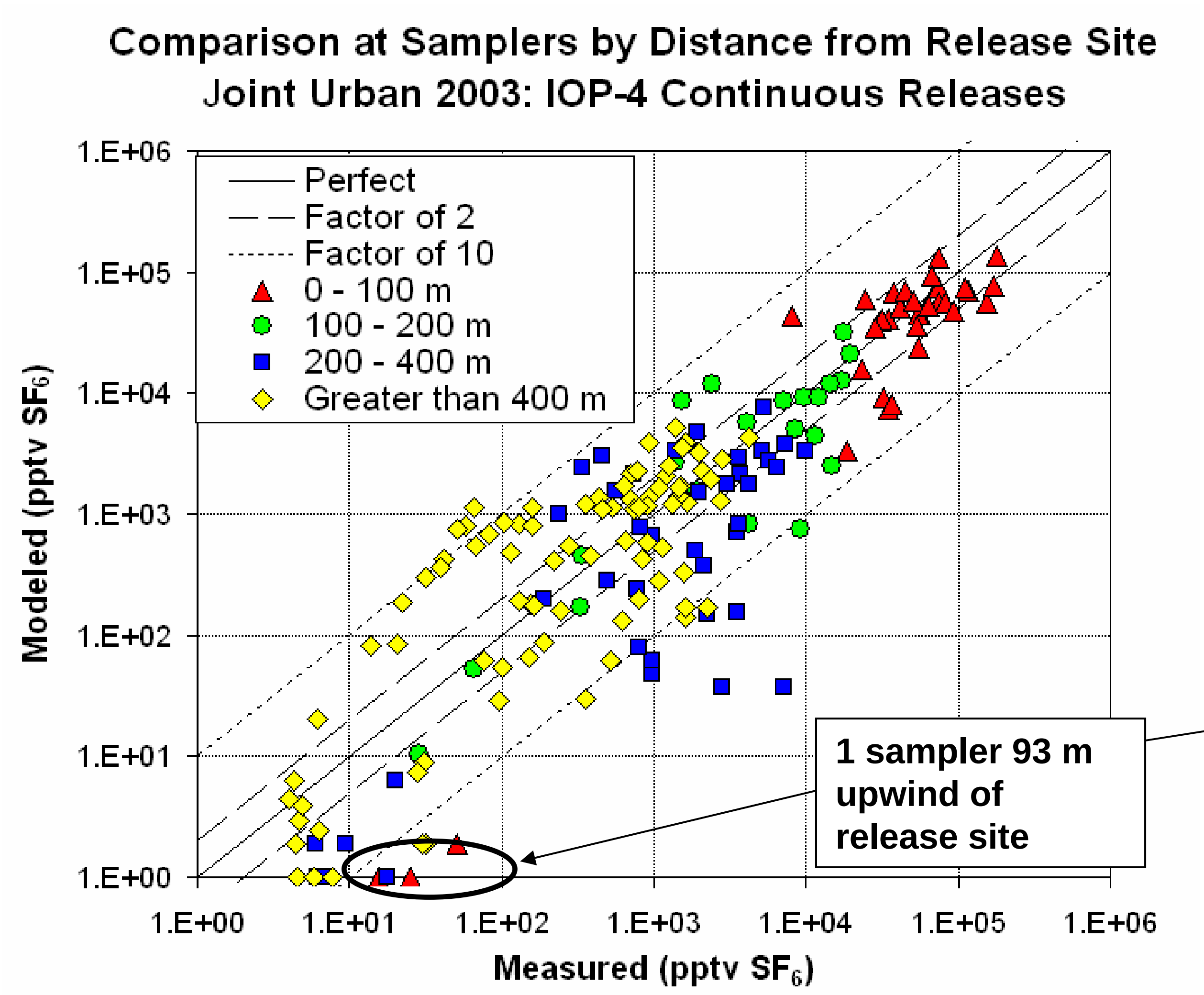


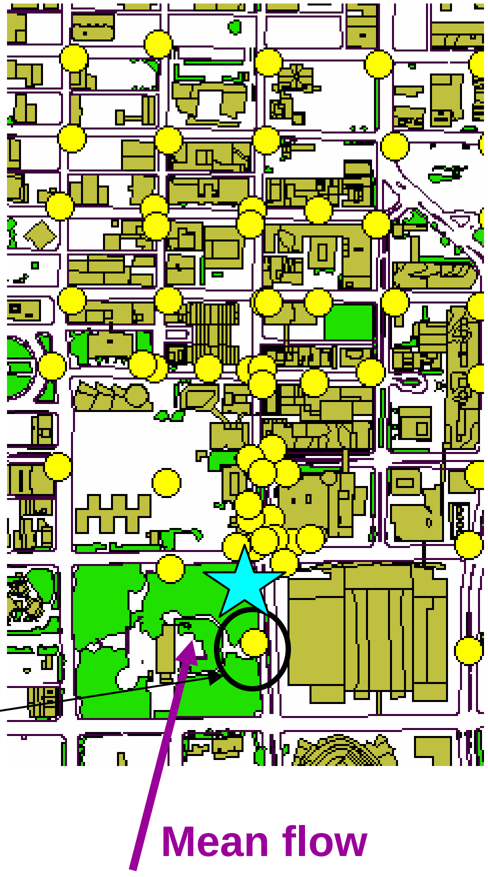
•Little change in correlation between model and sonic anemometers for averaging times from 40 seconds to 2400 seconds.

•Slight peak for 150 second averaging period.

•RMS error was a minimum from 60 to 150 second averaging time.

Validation of MESO/RUSTIC with Joint Urban 2003





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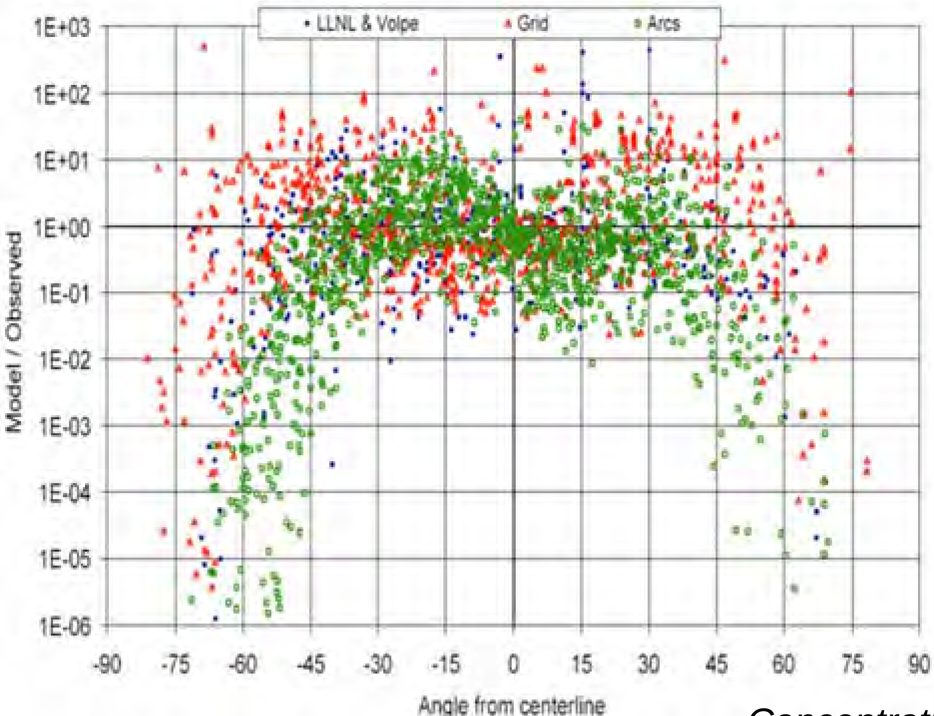
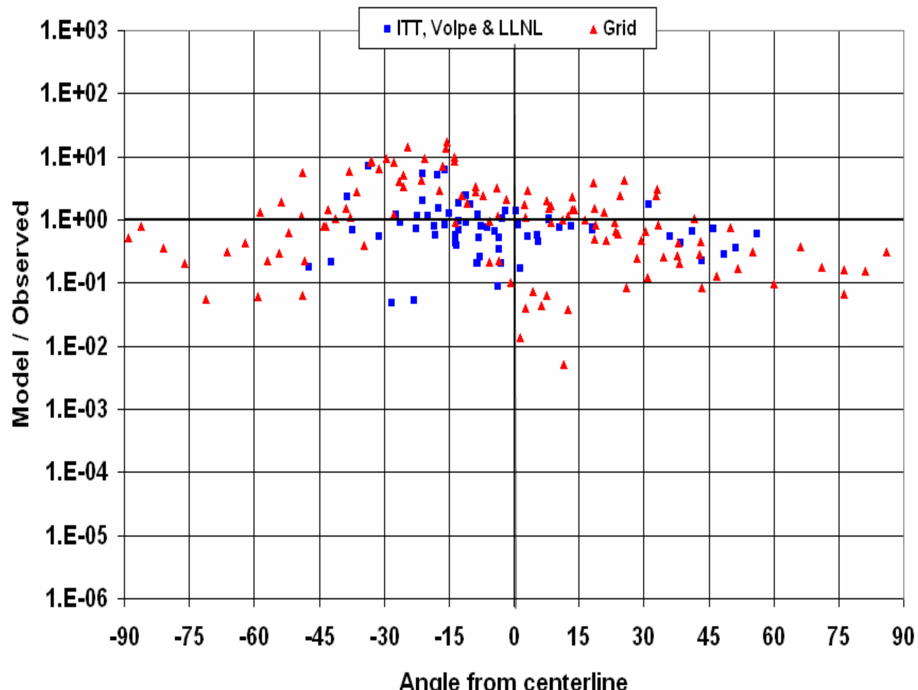
Plume Centerline Comparison to Joint Urban 2003
Gaussian plume model vs. MESO/RUSTIC





Concentration Ratios Plotted
Perfect Correlation is on 1E+00 Line

Gaussian Plume model simulation of all continuous releases of Joint Urban 2003 (Gouveia, 2004, preprints from the AMS Fifth Symposium on the Urban Environment)

MESO/RUSTIC simulation of the three continuous releases of IOP-4

DARPA

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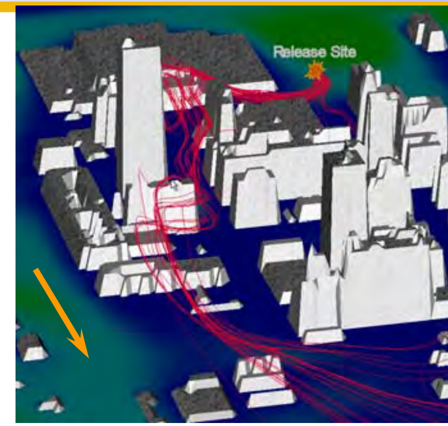
Improving RUSTIC for Coastal, Ocean and Rolling/Rough Terrain Areas (II.B.2.b) PI: Dr. Donald Burrows, ITT Corporation

Objective: To make major modifications to the existing RUSTIC flow code to permit fast high-fidelity predictions of dispersion in rolling/mountainous areas, coastal areas, and the open ocean.

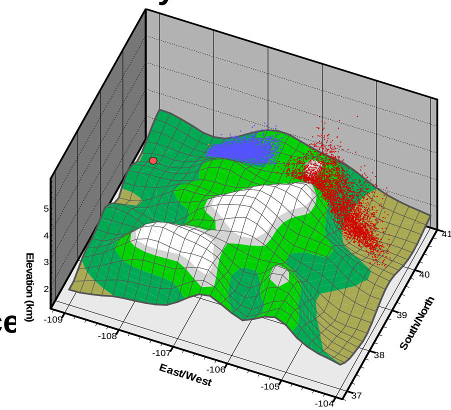
Description of Effort: Although very fast at modeling urban flow, RUSTIC can be modified to accurately model the objective stated areas requiring up to a 4-5 km thick boundary layer.

ITT will leverage the advanced NSWC second-order-closure (SOC) boundary layer model by adding it to RUSTIC. ITT will develop a heat flux model for water surfaces. Both are significant efforts. A large part of the project will be validation and documentation.



Streamlines Predicted by RUSTIC in OK City. Turbulence Produces Complex and Non-intuitive Flow (above).

The MESO simulation of the western ¾ of Colorado based on COAMPS (below) will be done by RUSTIC with SOC.



Benefits to Warfighter: Highly accurate estimates of hazard regions in rolling/mountainous areas, coastal areas, and the open ocean.

Challenges: Major modifications are needed to incorporating the SOC model into RUSTIC in a manner that keeps RUSTIC a fast tool.

Maturity of Technology: TRL 4-5. Both RUSTIC and the SOC boundary layer model are reasonably mature.

Capability Area: 2. Modeling & Simulation
b) Chemical/Biological Weapon Environment Prediction

Major Goals / Milestones by FY:

FY06 – Restructuring RUSTIC, installation of SOC model

FY07 – Develop surface heat flux model for water, code testing and verification, speed enhancements

FY08 – Documentation and validation

Could be integrated into ITT submittal E1. Different scopes can be made to accommodate tech-base needs.

PI contact info: Dr. Donald Burrows (719) 599-1840
don.burrows@itt.com

Coastal and Rolling RUSTIC Upgrades
JSTO Sponsored Tech Base Effort Begun in FY06

A. Increase area of coverage to tens of kilometers with a few hundred meters resolution

B. Modify RUSTIC to apply to areas with significant terrain in proximity to large bodies of water. ("Coastal and Rolling" RUSTIC)

C. Allow nesting of grids to provide detailed coverage of local areas with resolutions of a few meters

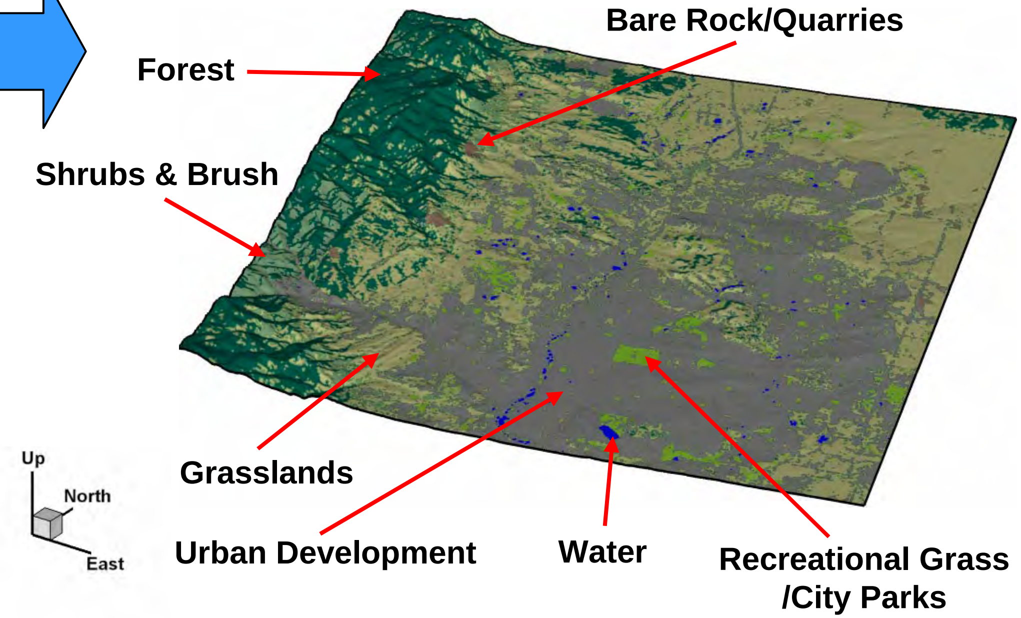
D. Goal is for RUSTIC to be initialized from a mesoscale forecast model and provide accurate wind predictions for areas of hundreds of sq km down to areas of less than 1 sq km.

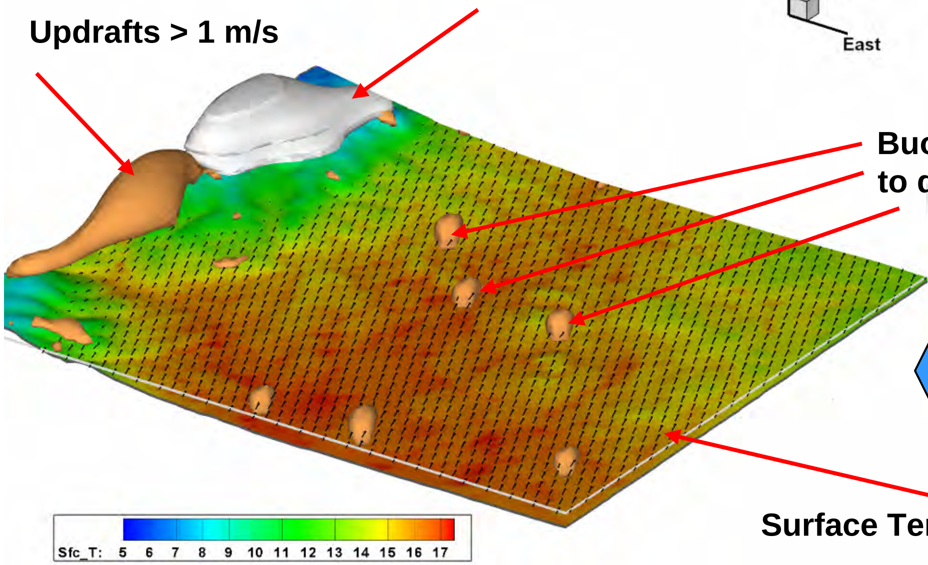
New York City Metro Area

RUSTIC Capabilities Recently Added for JSTO Tech Base Effort

1. Now uses 30 m resolution Land Cover data to describe surface characteristics.
2. A complete thermodynamic equation has been added.
3. Moisture physics has been added.

National Land Cover Data – Colorado Springs

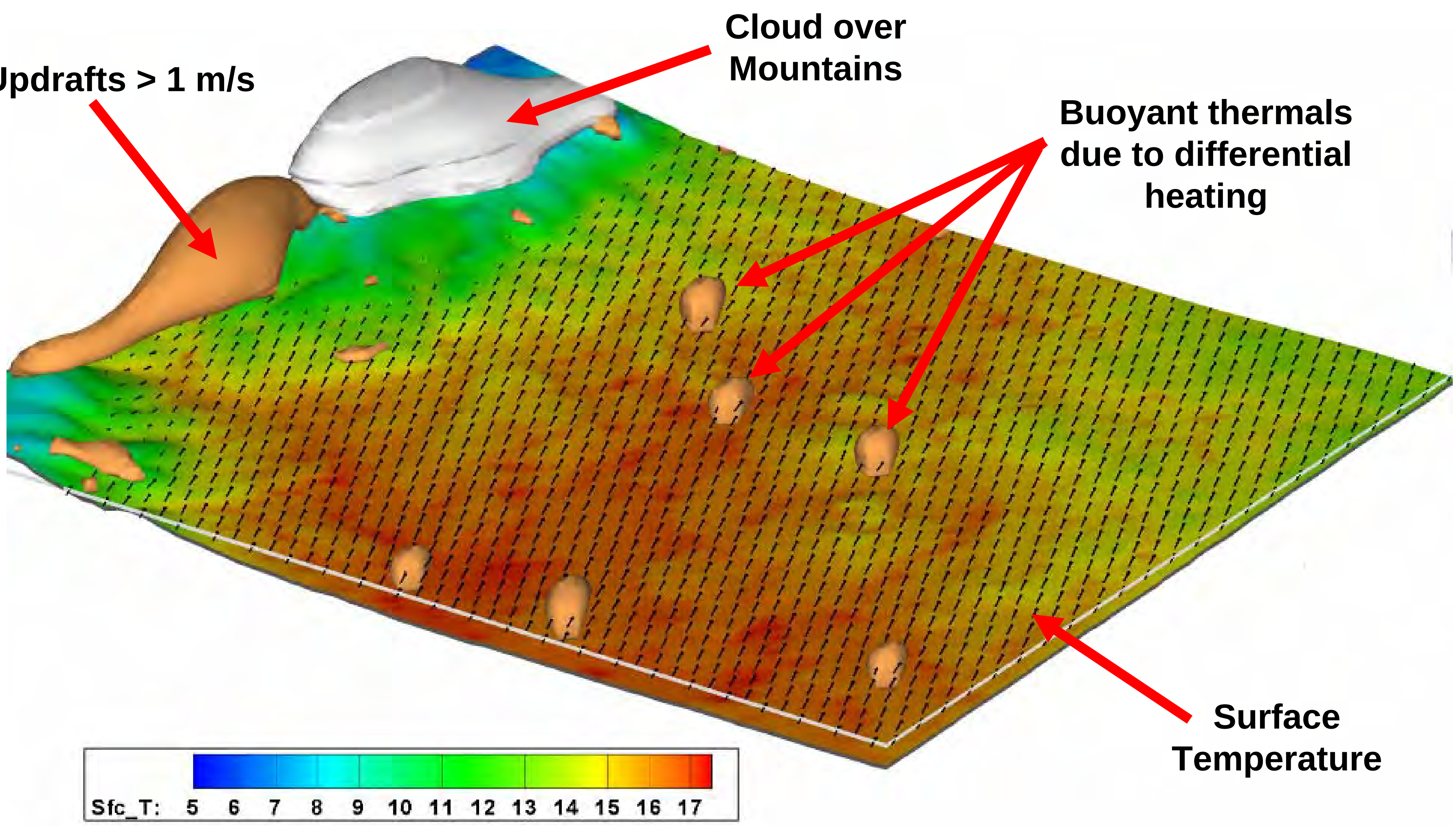




Simulation for Colorado Springs area with winds from 160 ° on a 20 km x 20 km grid

Unclassified

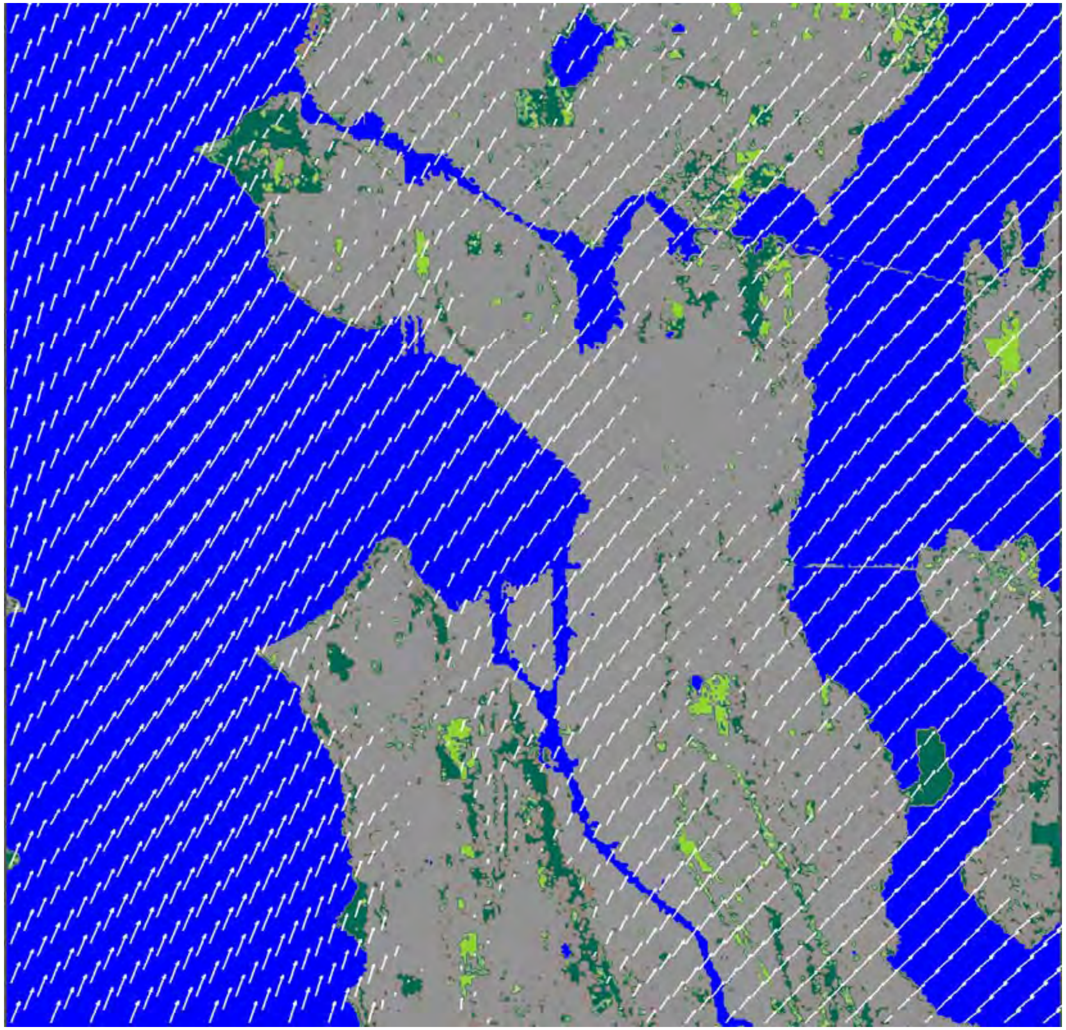
Recent RUSTIC Simulation for Colorado Springs Area for JSTO Tech Base Effort



Winds from 160° on a 20 km x 20 km grid

RUSTIC Capabilities Recently Added for JSTO Tech Base Effort

4. <u>Added:</u> The ability to make short range forecasts from mesoscale model inputs.
5. <u>Adding Soon:</u> The ability to update the boundary conditions as they change with time.



Example initialized from MM5 output
10 minute wind forecast for 100 m above sea level
2010 UTC
26 May 2006

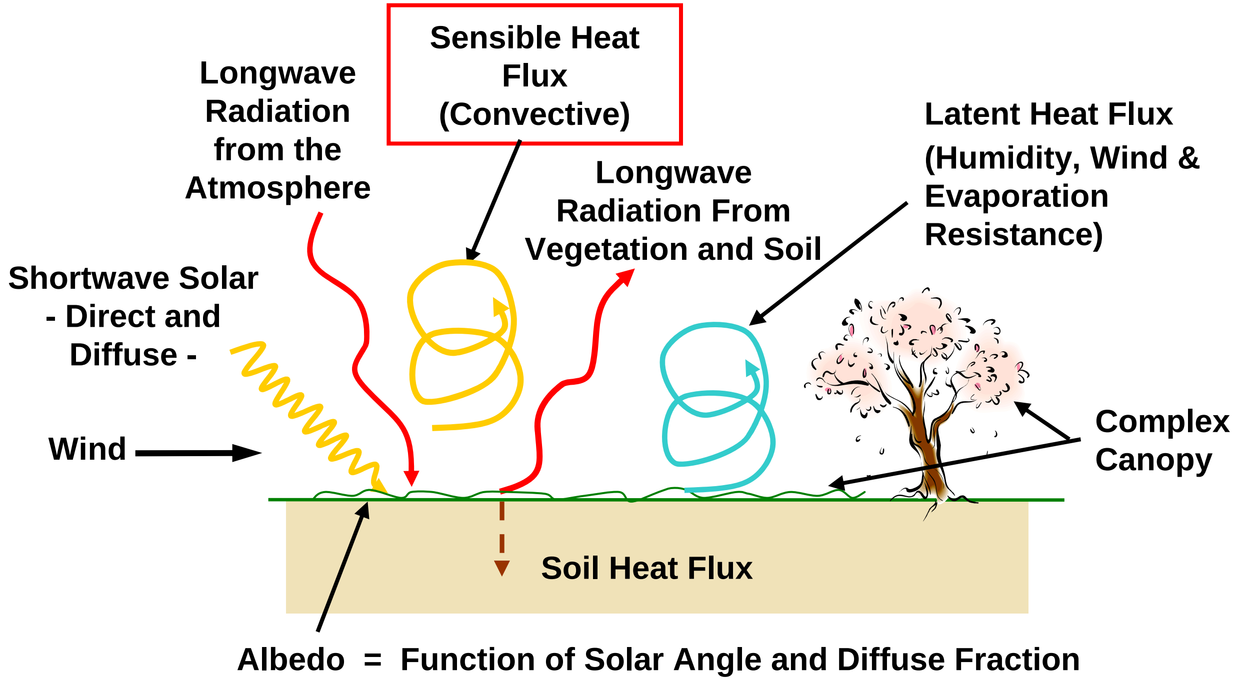
RUSTIC Upgrades in Progress for JSTO Tech Base Effort

6. Currently we are in the process of replacing the k-ω turbulence model with a Mellor-Yamada (1975) level 3 turbulence closure model.

7. The level-3 scheme employs prognostic equations for turbulence kinetic energy, k, and the mean magnitude of the temperature fluctuations, $\theta'^2/2$. Diagnostic equations are then solved for the moments: u'u', u'v', u'w', v'v', u'w', w'w', u'θ', v'θ', w'θ'.

8. The main coding of this algorithm into RUSTIC has been accomplished and debugging and verification of the code is in progress.

Future RUSTIC Upgrades Planned for JSTO Tech Base Effort



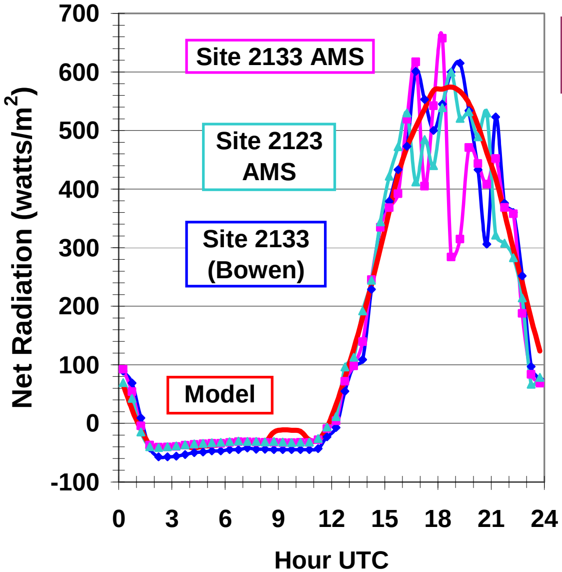
Heat Budget : *Solar (1 - albedo) + LWin - LWout = Net Radiation = Latent + Sensible + Soil*

9. **MESO has a sophisticated Heat Flux Model that is currently used with RUSTIC. The capability will be added to accurately model the heat flux over ocean surfaces**

Unclassified

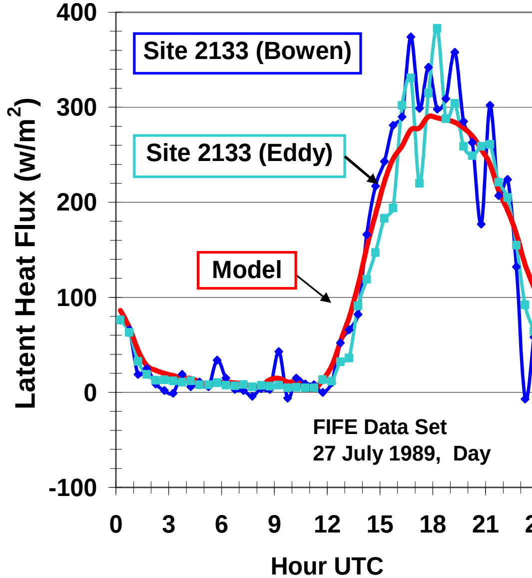
MESO’s Rigorous Heat Flux Model Compares Well with Data – Model for Water Will be Added to RUSTIC

Net Radiation

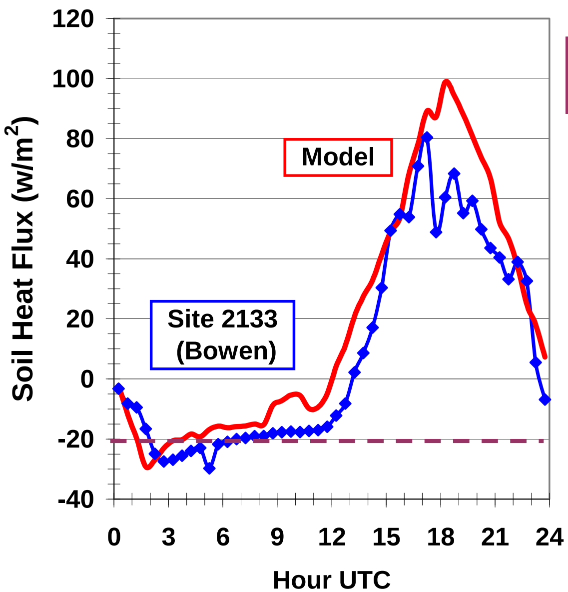


27 July 1989
Day 208

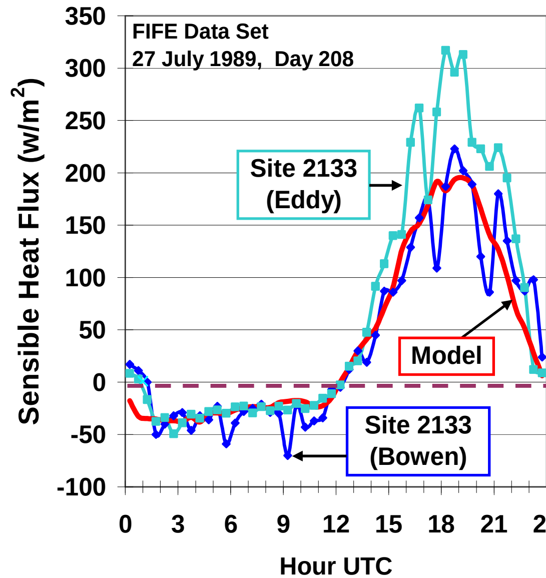
Latent



Soil



Sensible



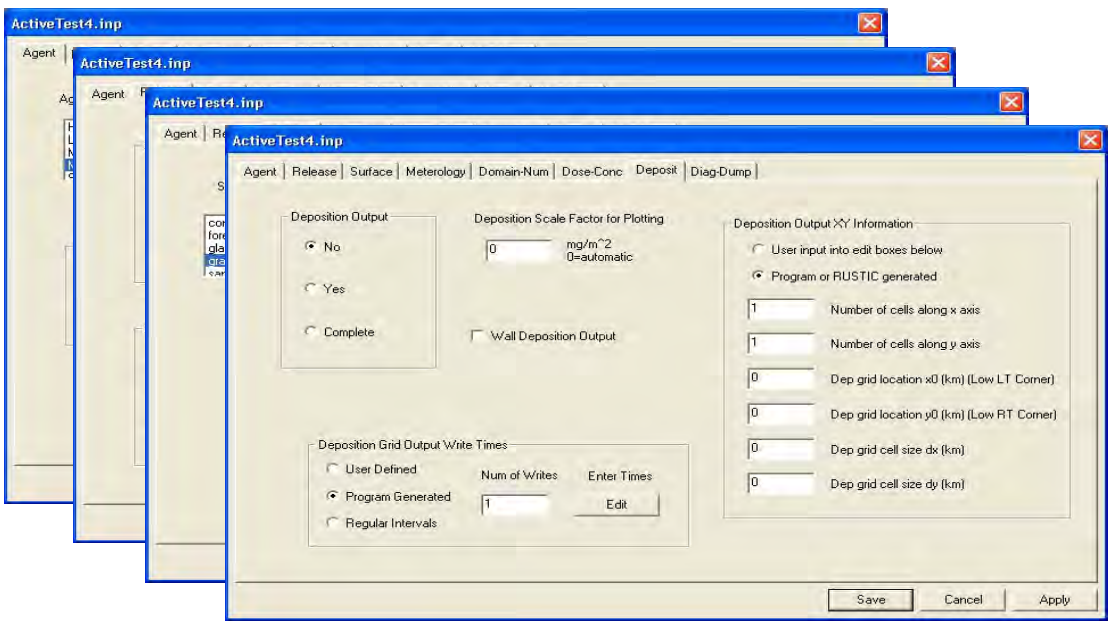
NAVSEA WARFARE CENTERS DAHLGREN

Unclassified

ITT

RUSTIC Upgrades Coming Next

- An API for MESO/RUSTIC was developed for MESO/RUSTIC as a part of the DARPA BPTK program.
- MESO/RUSTIC has been integrated with the Building Protection Tool Kit (BPTK) and is now being integrated with Dugway's NCBR code.
- A MESO/RUSTIC GUI that utilizes the API is nearing Beta release.



10. <u>**The new JSTO "Coastal and Rolling" version of RUSTIC will be incorporated in to the MESO/RUSTIC GUI**</u>

Recent Papers Accepted For Publication in Journal of Applied Meteorology and Climatology Joint Urban 2003 Special Issue

1. **Modeling Turbulent Flow in an Urban Central Business District.** D. A. Burrows, E. A. Hendricks, S. R. Diehl, R. Keith.

2. **Urban Dispersion Modeling: Comparison to Single-Building Measurements.** S. R. Diehl, D. A. Burrows, E. A. Hendricks, R. Keith.

3. **Evaluation of a Fast-Running Urban Dispersion Modeling System with Joint Urban 2003 Field Data.** E. A. Hendricks, S. R. Diehl, D. A. Burrows, R. Keith.

End of Presentation

Any Questions?

Test Technology Division

West Desert Test Center,

U.S. Army Dugway Proving Ground

GENERAL DYNAMICS
Information Technology

A New M&S Tool to Supplant Decontamination Testing: The Decontamination Efficacy Prediction Model (DEPM)

January 11th, 2007

2007 NDIA Chemical and Biological Information Systems Conference

Austin, Texas

Approved for public release; Distribution unlimited

Authors

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General Dynamics Information Technology

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Briefing Outline

- History/Background
- Model Structure
  - Key Object Classes
  - Key Objects
- Agent Flow Diagrams
  - Contamination & Aging Phase
  - Decon Phase
  - Residual Hazard Phase
- Questions?

History/Background

Historical Background

- Initiated in 2003 as the Equipment Contamination Survivability Tool (ECS), funded by the VPG Program
- Initial phase was survey of existing models and databases
- In 2005 Anteon Corp. was selected to begin model design
- Proof-of-principle prototype demo'ed in Sep. 2005 at DPG
- With VPG termination in 2006, project is now funded by DTRA, with ECBC performing live agent testing
- Modeling effort now focused on simulating coupon testing of various materials in a chamber environment
- Model renamed to Decon Efficacy Prediction Model to reflect new focus; Anteon now part of GDIT

What is the Decontamination Efficacy Prediction Model (DEPM)?

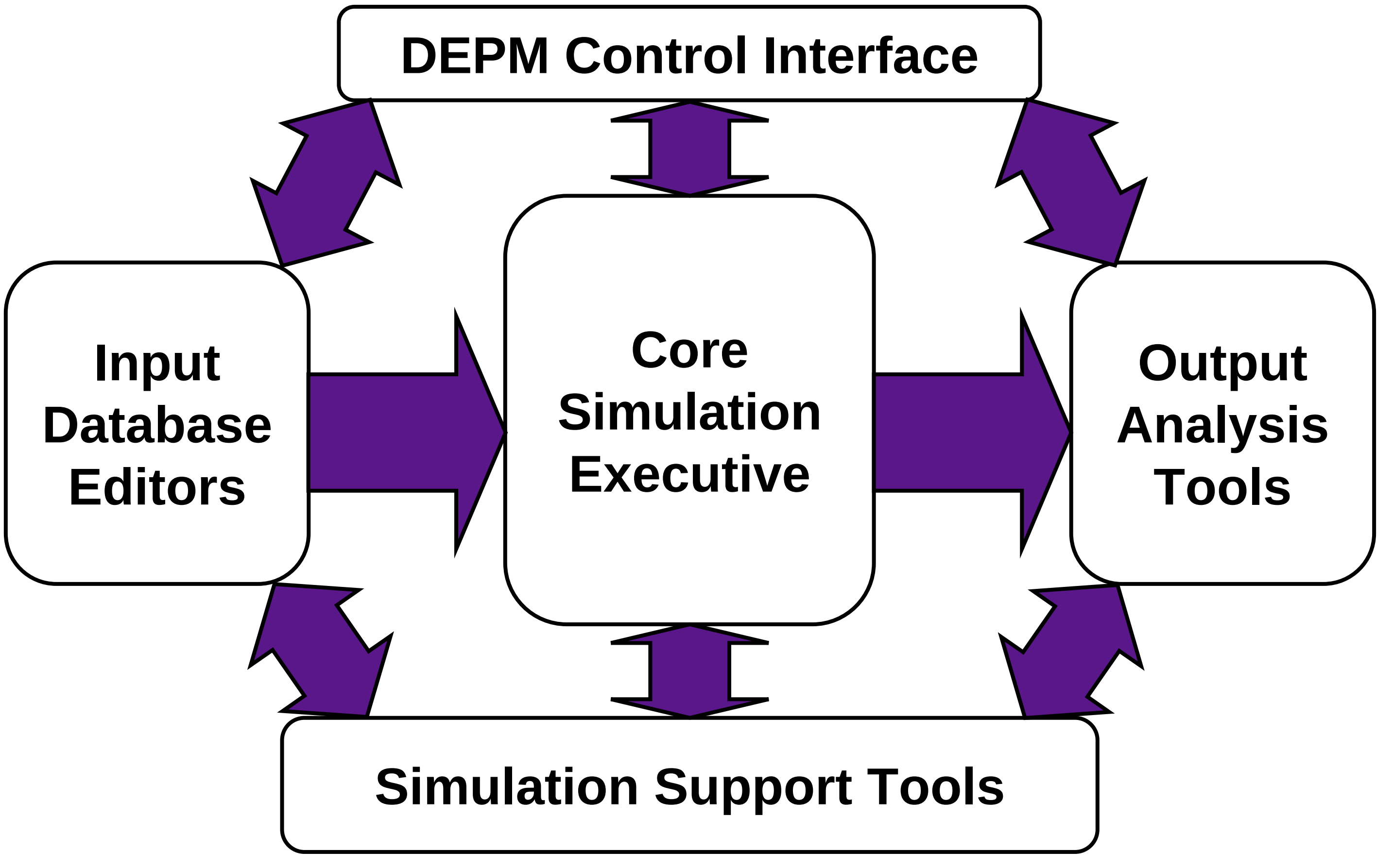
- The DEPM is a software tool that will simulate the contamination/aging/decontamination of material items
- Usable model prototype to be ready early 2007
- Provides a “Virtual Chamber” to subject simulated items to the four key phases:
  - Contamination
  - Aging
  - Decontamination
  - Residual Hazard

Potential Benefits of the DEPM

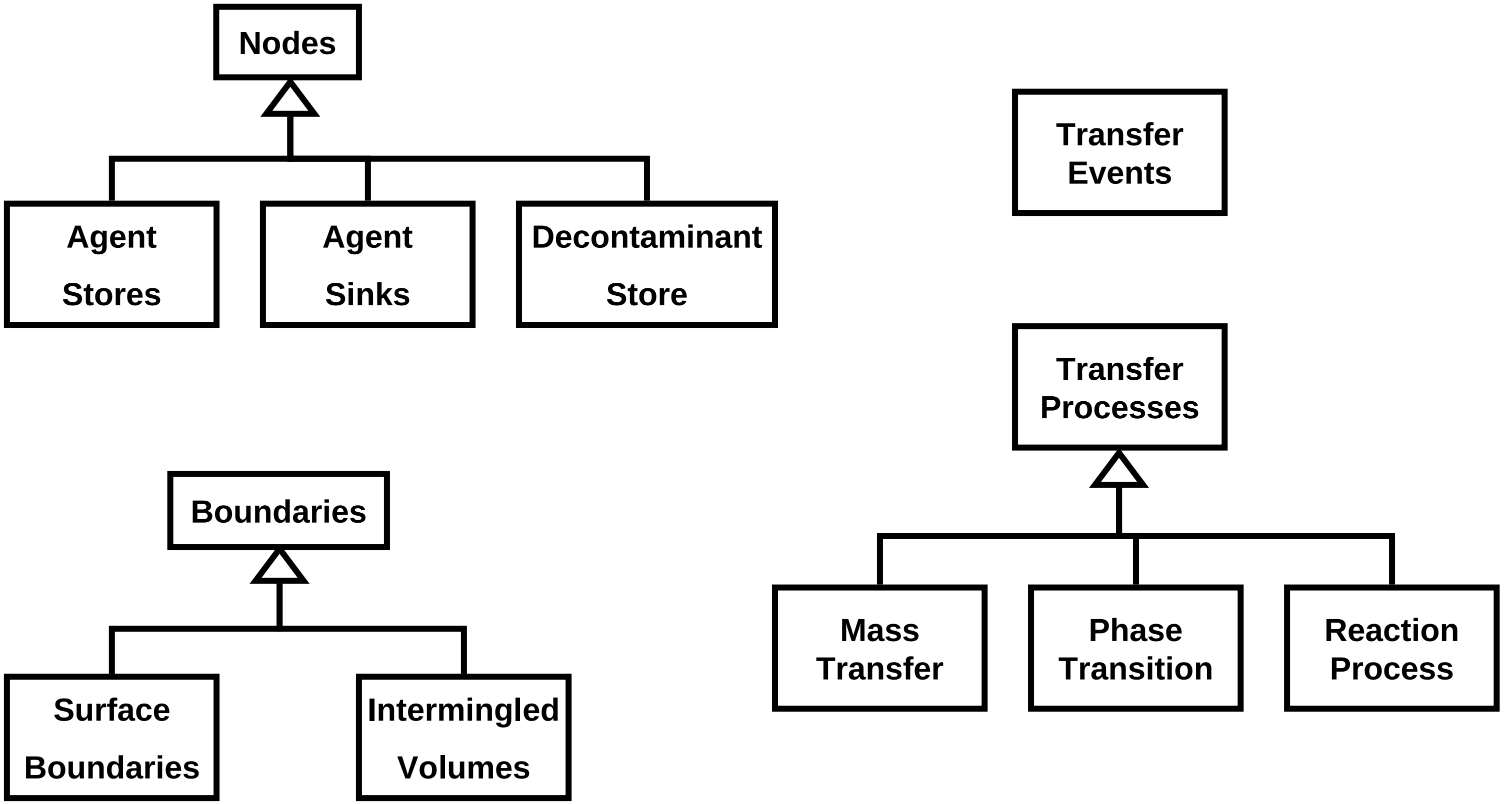
- Not meant to replace all laboratory tests – will complement
- Allows paring down of live testing case matrices
- Allows a wider spectrum of contamination and environmental conditions to be explored
- Provides a platform to test complex items or collections of items – testing not generally possible in chambers with live agent

Model Structure

DEPM Model Structure



Key Object Classes (Generalized)



GENERAL DYNAMICS
Information Technology

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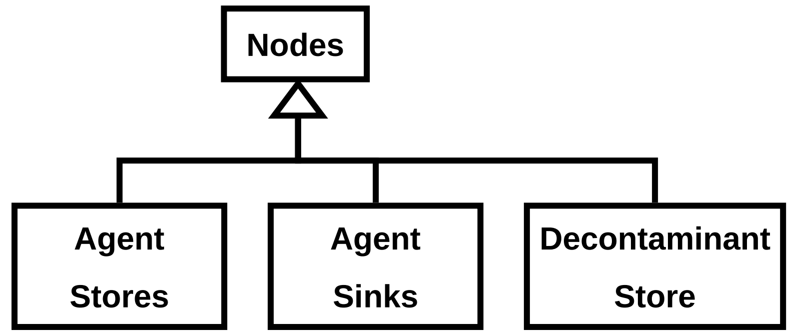
Stores and Sinks Object Classes

- **Objects of these classes "contain" quantity of agent or decontaminant**
- **Mass can transfer into or out of Stores**
- **Mass can only transfer into Sinks**
- **A store is assumed to be of homogenous material**



- **Key Object Attributes:**
  - **Current Mass (**units: *mass***)**
  - **Rate of Change (**units: *mass/unit time***)**

Transfer Event Object Classes

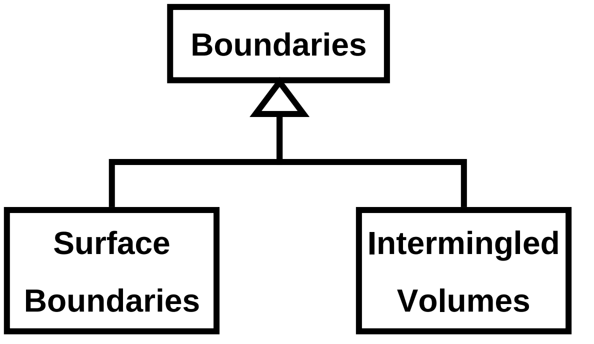
- Transfer Events Objects are used to represent the transfer of agent mass into or out of a store/sink that is assumed to occur at a discrete point in time (rather then over a period of time)

Transfer Events

- Key Object Attributes:
  - Varies by Specific Object
  - Typically: mass, percent/fraction transferred, etc.

Boundary Object Classes

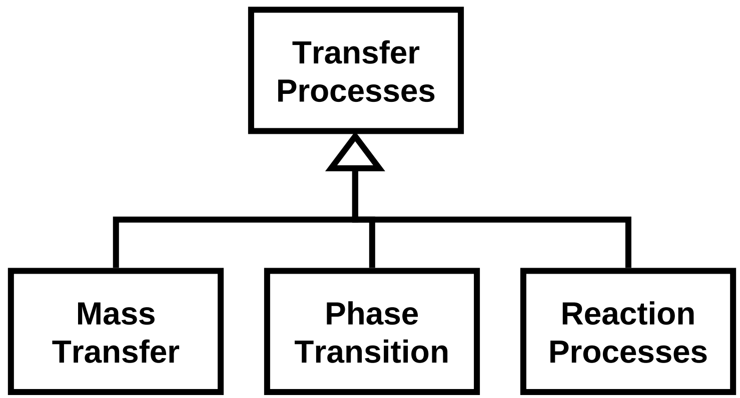
- **Boundary Objects represent the “boundary” between agent stores/sinks**
- **These objects work with Transfer Process Objects to represent the flow of agent from store to store/sink**
- **“Intermingled Volumes” are used to represent the boundary between agent/ decontaminant stores that occupy the same “space” – typically used with reaction processes**



- **Key Surface Object Attributes:**
  - **Surface Area (**units: *area***)**
- **Key Volume Object Attributes:**
  - **Volume (**units: *volume***)**

Transfer Object Classes

- Transfer Objects work with Boundary Objects to represent the transfer/ transformation of agent mass between stores and sinks



Agent Flow Diagrams

Agent Flow Diagrams

- The following slides show the general flow of agent mass from store to store/sink via boundaries using various transfer processes

Agent

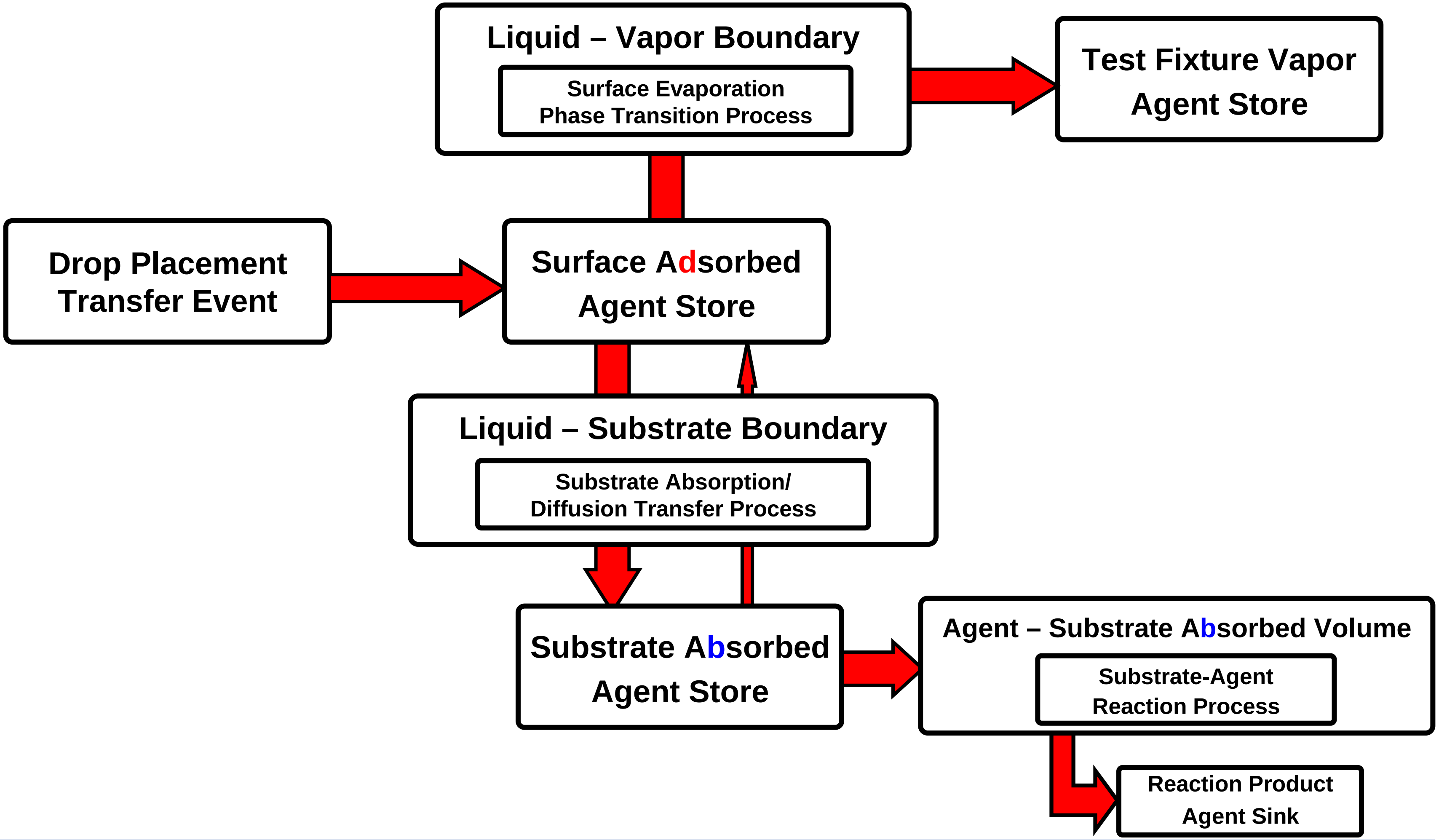
Decontaminant

Reaction Product

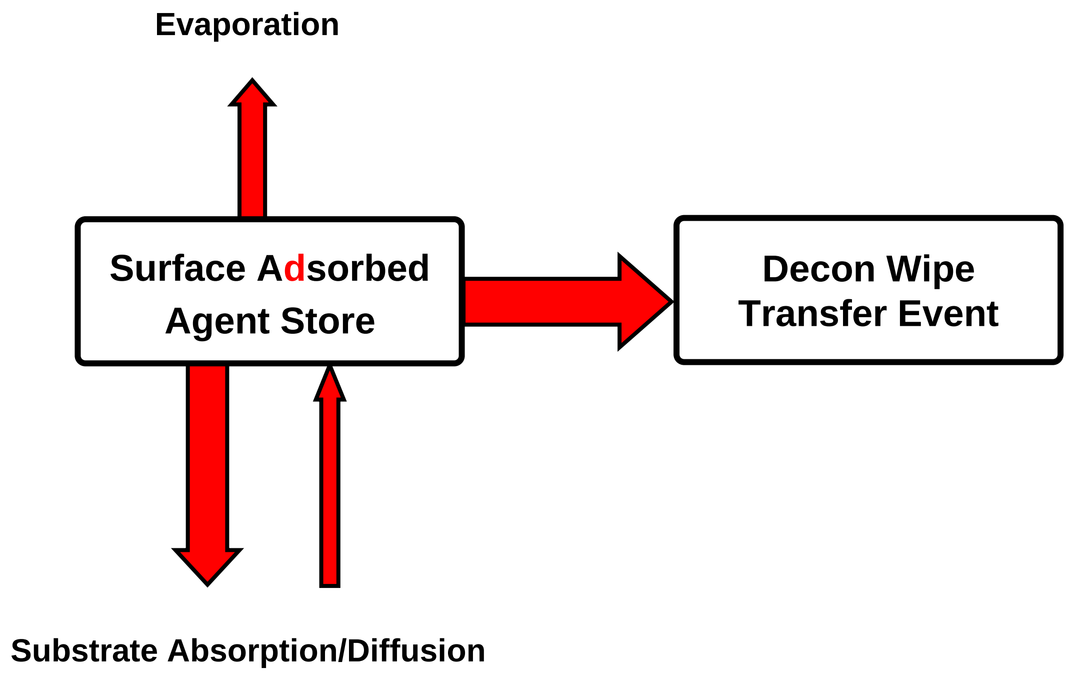
Phases Represented in Simulation

- Contamination & Aging
- Decontamination
  - Physical Removal
  - Vapor – Vapor Decon
  - Surface Decon
  - Substrate Penetration Decon
- Residual Hazard
  - Residual Evaporation
  - Contact Hazard

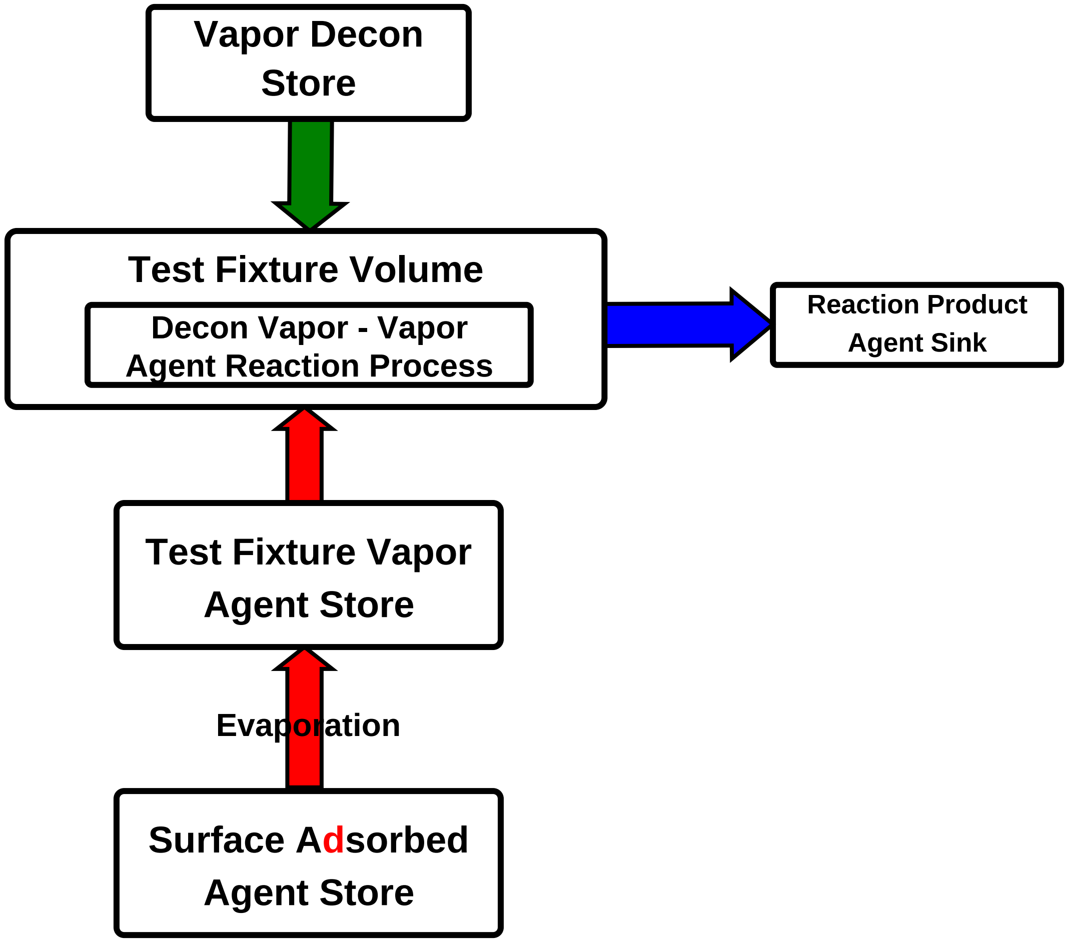
Agent Flow: Contamination & Aging Phase



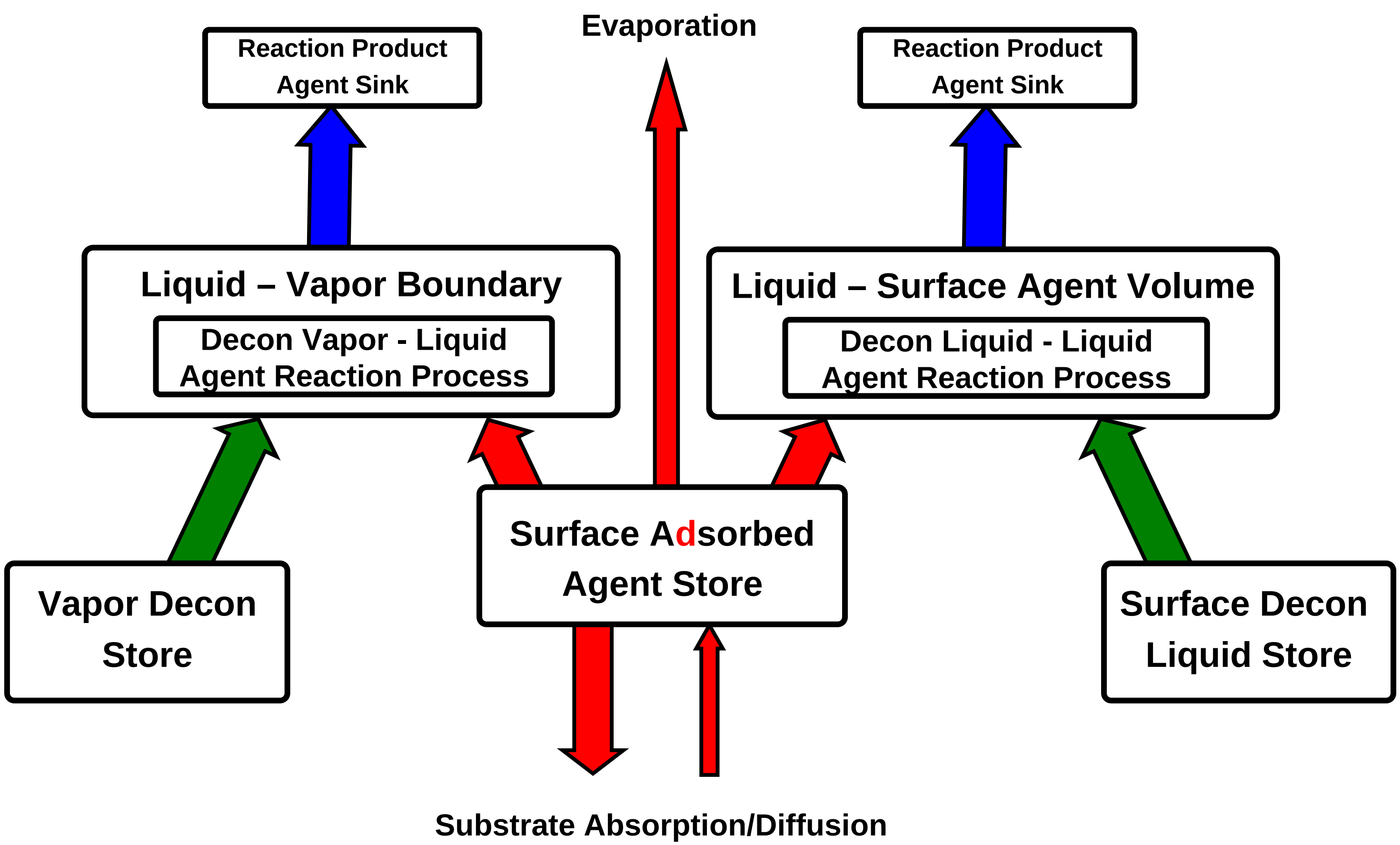
Agent Flow: Decontamination Phase (Physical Removal)



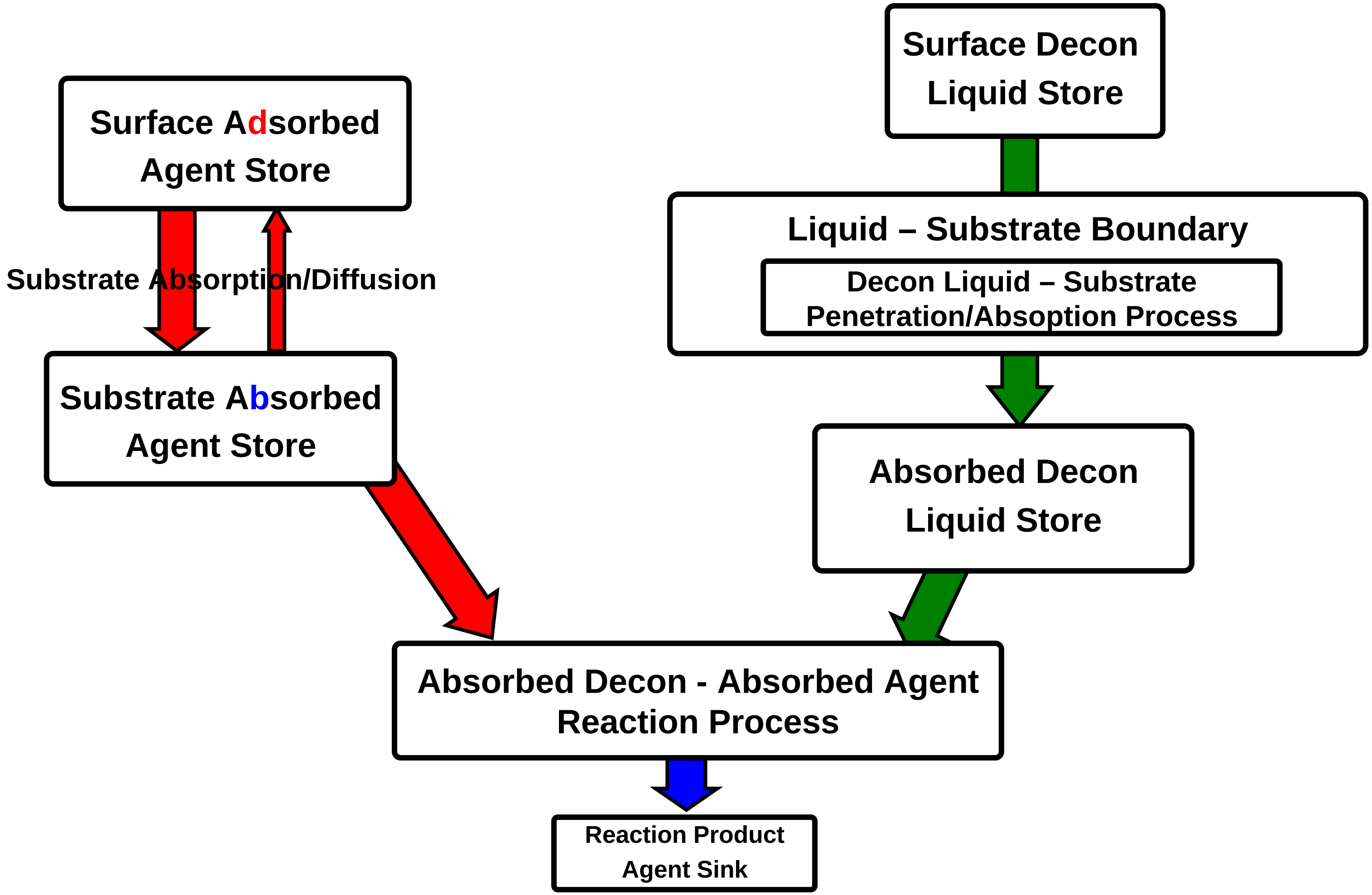
Agent Flow: Decontamination Phase (Vapor - Vapor Decon)



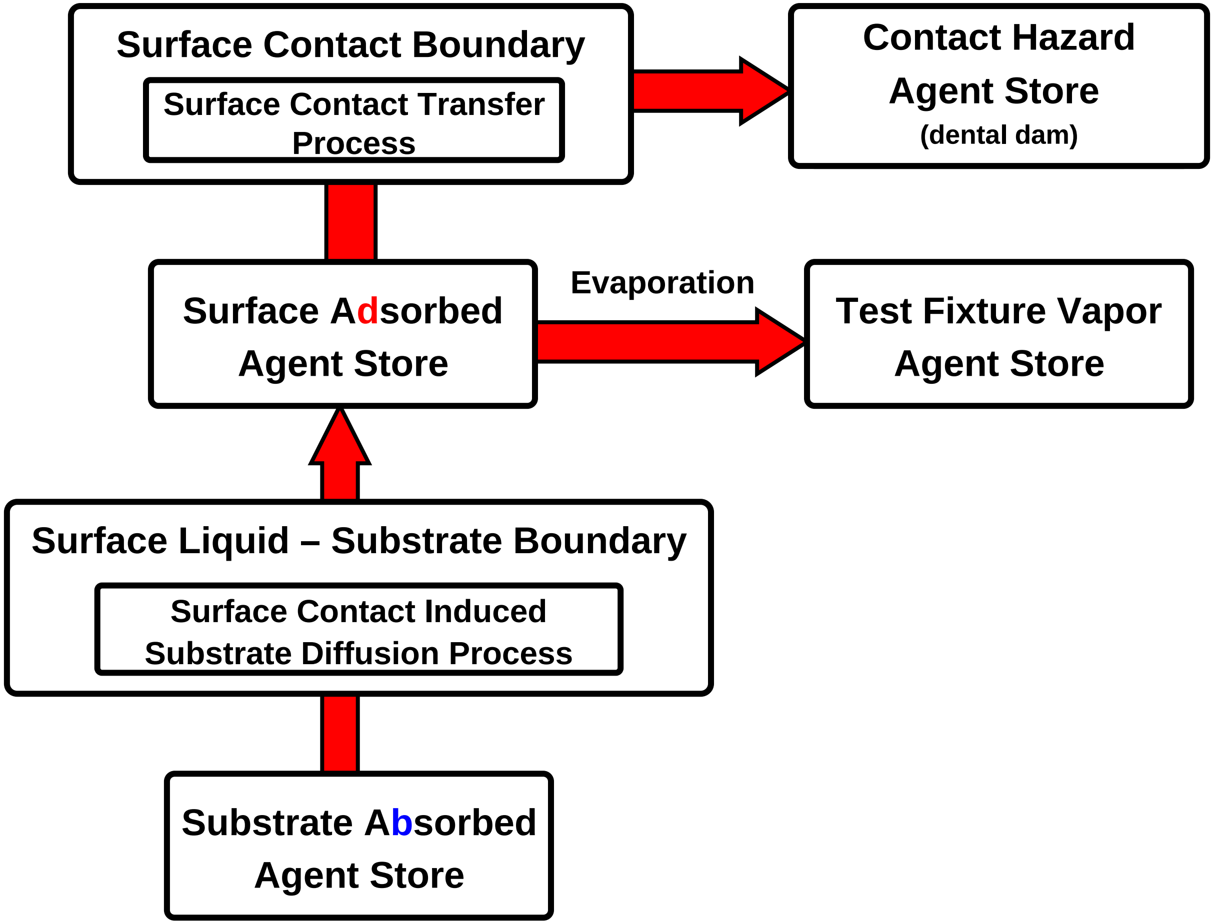
Agent Flow: Decontamination Phase (Surface Decon)



Agent Flow: Decontamination Phase (Substrate Penetration Decon)



Agent Flow: Residual Hazard Phase



In Summary

- Proof-of-Principle Prototype (as the ECS Model) has been completed and demonstrated at end of FY05
- Current development effort is projected to reach limited decontamination efficacy prediction capability by early CY07
- Incorporation of more detailed and advanced functionality will continue in FY07 to allow for more realistic simulations of live agent coupon contamination, aging, and decontamination, the level of effort commensurate with funding

Questions?

Development of CBRN Impact Assessment Capabilities

Christopher Clem

Defence Science and Technology Laboratory, UK

UK UNCLASSIFIED

Introduction

- Impact assessment studies provide a valuable insight into the effectiveness of defensive equipment and procedures with respect to causalities and effects on operations.
- They provide the capability to assess the level of casualties when faced with a CBRN incident and evaluate the effect on the operation.
- There are benefits to be gained from CBRN impact assessment studies therefore the requirement to develop tools to support them exists. So how do we do it ?

Introduction Cont.

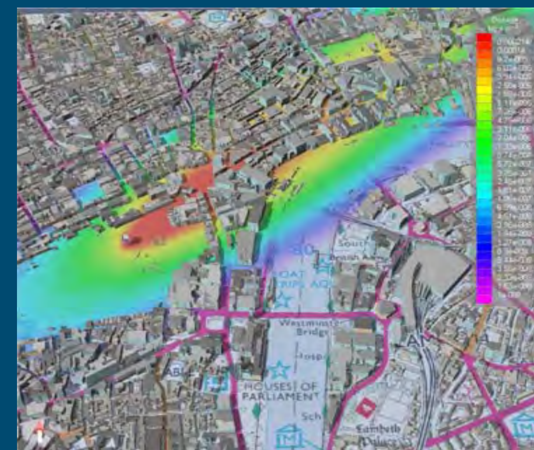
- Tools, such as JOEF and the MOD's Virtual Battlespace, can be used to
  - support the equipment acquisition programme
  - aid pre-operational planning
  - assess the operational implications of concepts, doctrine and technology development
  - guide the research programme
  - aid CBRN training

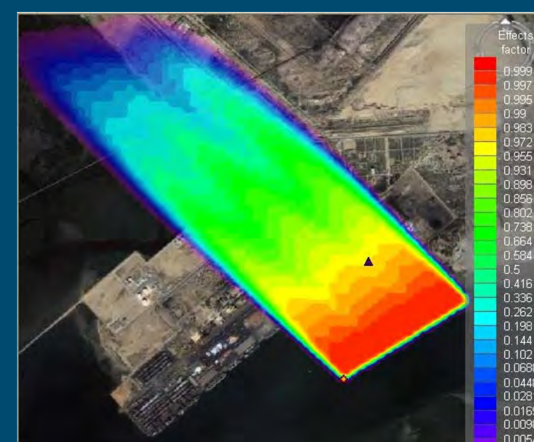
Developing Dstl’s Capability

- As part of the UK MoD’s strategy Dstl has developed a chemical and biological defence operations research tool, called the Virtual Battlespace (VB).

- The VB allows the user to create scenarios for analysis and vary parameters, based on statistical distribution and Monte Carlo sampling.

- The VB is currently being used under two programs of work for the JSTO. The ‘Impact Assessment Tool’ and ‘CBRN in Theatre and Tactical Level Simulations’.



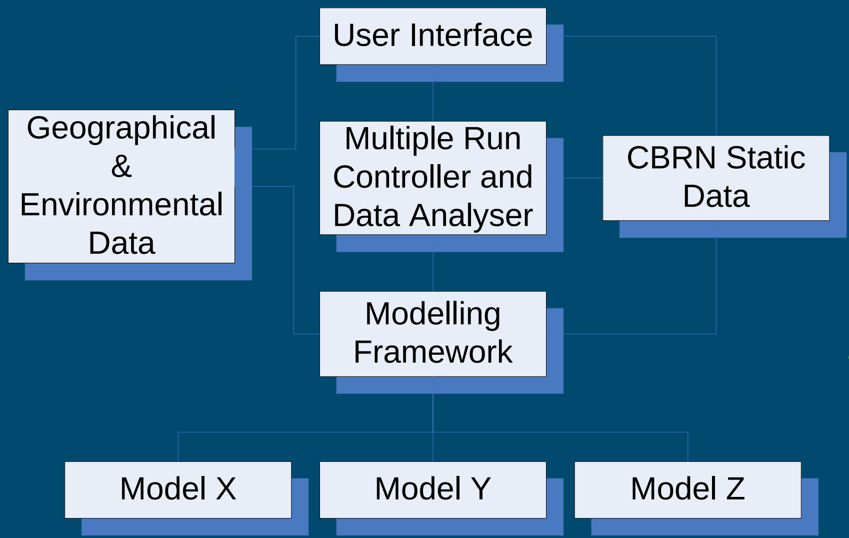


What is the Virtual Battlespace?

- A synthetic environment including (some under development)
  - State-of-the-art dispersion models (UDM & SCIPUFF)
  - Models of CBR defence system (detection, protection, MCMs)
  - Representation of movement of entities (aircraft, army units)
  - Links to combat & facility models (WISE, OneSAF, STAFFS)
  - Multiple run controller
  - Wargaming mode

The Virtual Battlespace Models

- Dispersion Modelling
  - CBR sources and hazard plumes (weapons, IEDs, RDDs, TICs & TIMs)
  - Urban and Rural (SCIPuff & UDM)
  - Concentration Realisation
- Meteorology
  - Terrain
  - Local Wind Turbulence
  - Sea Breeze



- Military Units/Personnel
  - Effects (casualties)
  - Inhalation & Contact Hazard (liquid pickup)
  - Medical Countermeasures
  - IPE
  - Physiological Burden
  - Aggregation
  - Value of Information
- Detectors
  - Simple (threshold)
  - Generic
  - Specific
  - Standoff
  - Biological Background
  - Single & Network Alarms
- Modes of Use
  - Wargaming
  - Assessment

Operational Effects

- The Virtual Battlespace predicts the impact of CBRN on personnel, equipment and terrain

- In general, this will be done by linking or inputting to appropriate high-level modelling tools
  - This can include both simulations and wargames
  - Physical link was investigated to UK WISE (formation level simulation)

The Challenge

- An issue with CBRN Impact Assessment lies with the level of fidelity the user wishes to run the model at. It is not feasible to run every scenario at a high level of detail down to individual units.
- One way to overcome this is to link a CB effects model with event based models. E.g. STAFFS, Combat 21, and OneSaf to provide CB effects at the models native level of detail.
- This approach provides more accurate representations, but the inherent challenge becomes the methodology by which the effects can be aggregated between the different levels of models in use to provide the overall CBRN Impact Assessment Capability.

CBRN in Tactical and Theatre Level Simulation (II.B.2(c) Bullets 1 & 2)

UK UNCLASSIFIED

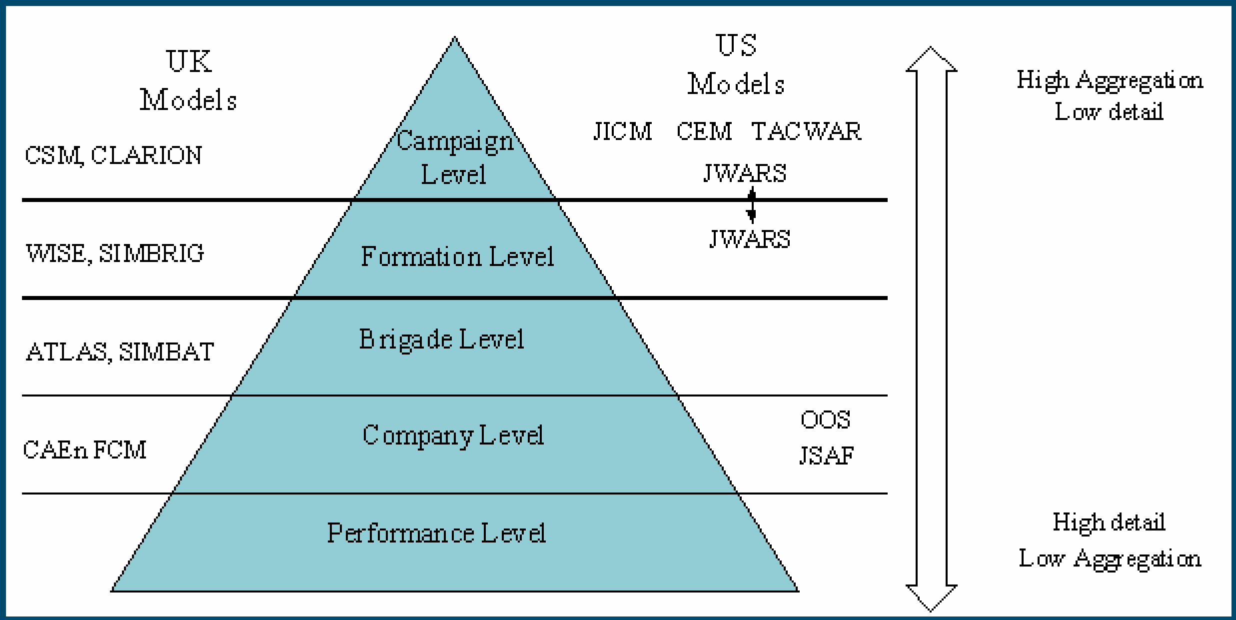
Introduction

- JSTO funded work targeted at the JOEF program of record.
- Work to take place over 4 years.
- The aim of this work is to provide a capability for carrying out assessment studies for mobile forces, which supports several levels of aggregation and links to existing theatre/tactical models.

Background

- It is a military aim to have the ability to maintain political and military freedom of operations in the presence or threat of CBRN weapons.
- Warfare simulations exist at various levels of detail. Each could have its own CBRN effects.
- A more pragmatic solution is to have one effects model and apply it to all levels of simulation systems.

Example of simulation levels



Many of these existing simulations do not contain a representation of CBRN, others only contain a simplistic representation.

Military Significance

In order to achieve political and military freedom of operation it is necessary to quantify the effects of CBRN on mobile forces in terms of:

- Causalities
- Decreased operational Effectiveness
- Command and Control structures.

In Theatre or Campaign level engagements effects that need to be quantified are :

- The effect on the outcome of the campaign
- The effect on the duration of the campaign
- The effect on casualty levels (are they acceptable?)

Military Significance (2)

This tool could be used to provide capability in the following areas :

- Planning and Risk Assessment/Management

At a preoperation stage where the effects on a proposed operation can be quantified in terms of operational effectiveness and collateral damage.

- Doctrine Development

The tool could allow the analysis of different CBRN doctrine decisions. For example at what point individuals react to detector alarms. The effect of these decisions could be quantified providing important information to doctrine developers.

Work Breakdown

Year 1

- Conduct a study of existing tactical and theatre level warfare simulation models. The objective being to select one of each for future integration.
- Develop an aggregation strategy and implement it within Dstl's existing CBRN modelling and operational research system.

Year 2

- Begin integration of CBRN effects with the chosen tactical model.

Year 3

- Finish integration with tactical model, begin integration with theatre level model.

Year 4

- Complete integration with theatre model and provide a software and documentation release.

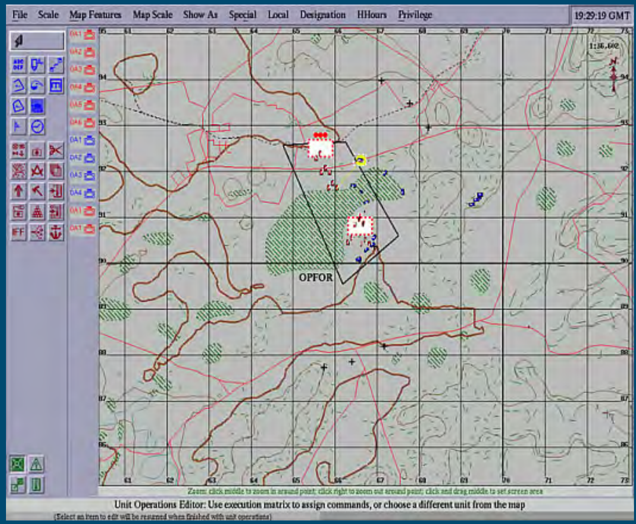
Models

Tactical

- OneSAF / JSAF
- Combat 21
- AMP (Analysis Mobility Platform)

Theatre

- JWARS
- JICM
- TACWAR



The Challenge

- Thoroughly assess the model candidates to link with
- Develop appropriate aggregation and disaggregation approaches
- Ensure the overall system can be run in an acceptable time
- Remain focused on the benefits and relevance to the development of future increments of JOEF.

Questions ?

Progress Towards An Improved High-Fidelity Forecasting Capability using Combined Mesoscale and Microscale Models

Presented by
William J. Coirier, Ph.D.
at the

2007 Chemical and Biological Information Systems Conference

Hazard and Environmental Modeling Session

Austin, TX

Thursday, January 11, 2007

Outline

- Summary of the SBIR Phase I Findings
- Overview of coupling framework using MCEL
- CFD Model and Related Software Development Overview and Progress
    - Cartesian Adaptive Mesh Refinement-based Virtual Cell Embedding
    - Specialized Parallel RANS Solver
    - Wind library database and common file format
- Work plan

Acknowledgements

- This work is funded under a Small Business Innovation Research Phase II grant:
    - CDR Stephanie Hamilton/USN
- NCAR:
    - Dr. Fei Chen, Dr. John Michelakes, Dr. Jimi Duddhia
- Bettencourt Consulting (MCEL):
    - Dr. Matt Bettencourt
- CFDRC:
    - Sura Kim, Shawn Ericson, Saikrishan Marella, Joel Mayes

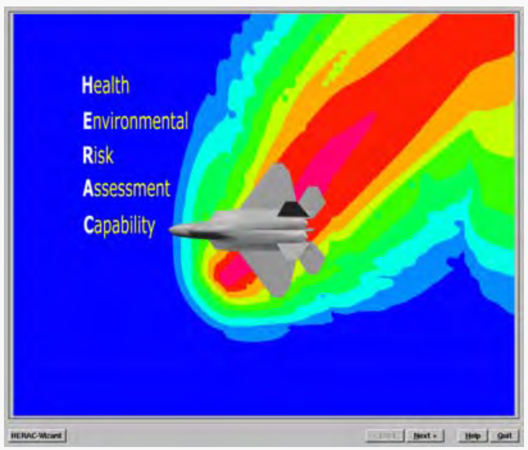
Defense Applications Branch

Mission

Support the DOD, DHS, DoE and Industrial Customers via Technology Transfer of First-Principles Based Scientific Computing Applications and Methodologies

AFFTC Edwards AFB

Health and Environmental Risk Assessment Capability: HERAC

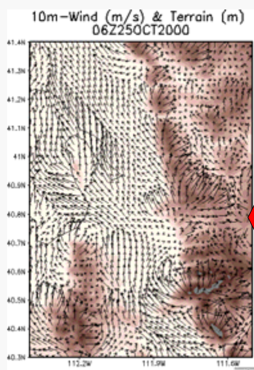


CFD-based Risk Assessment for A/C Maintenance

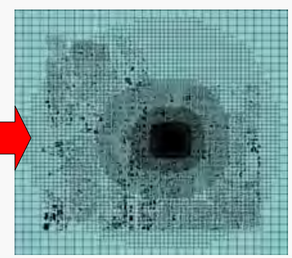
DTRA

Coupled Micro- and Mesoscale Weather Models

WRF



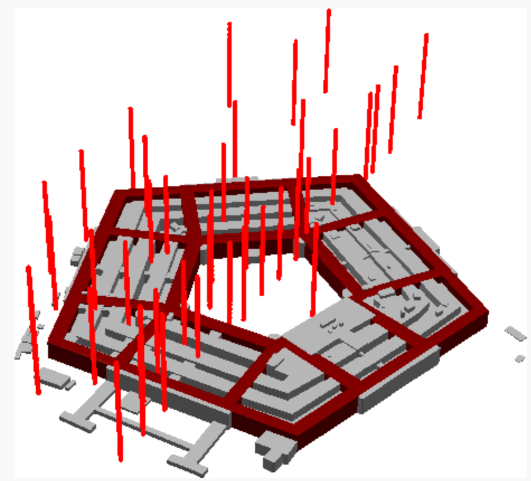
CFD



Improved High-Fidelity Microscale T&D via Coupled NWP and CFD

PFPA/DARPA

Pentagon Shield CFD Model Component



Operational Force Protection System to Guard against CBRN/E

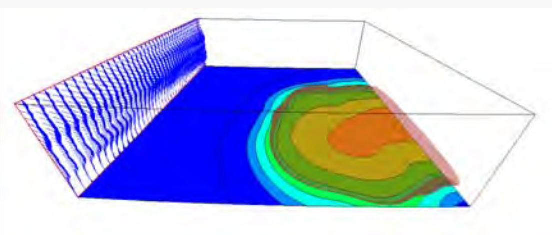
Defense Applications Branch

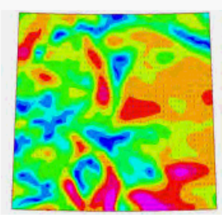
Mission

Support the DOD, DHS, DoE and Industrial Customers via Technology Transfer of First-Principles Based Scientific Computing Applications and Methodologies

DTRA

Real-Time 3D Visualization Capability

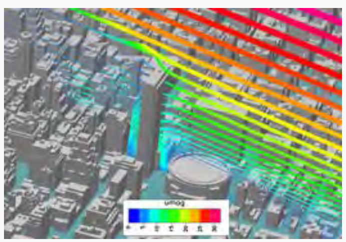


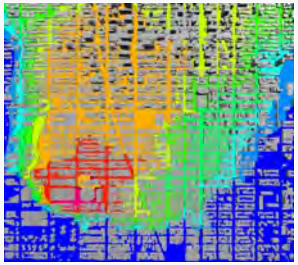


Client/Server Visualization Capability for Next Generation Consequence Assessment Models

DHS/DTRA

CFD Support for National Field Tests

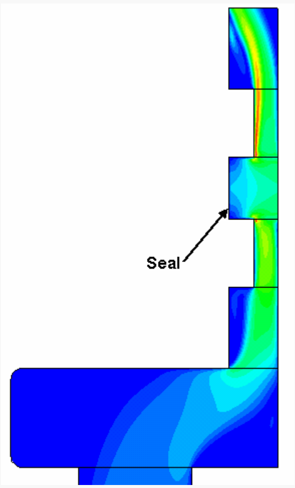


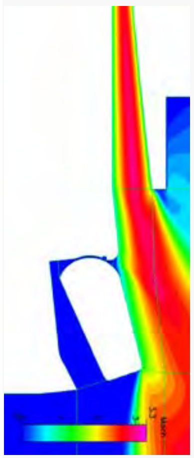


Transport and Dispersion Studies Pre- and Post-Test, Urban Dispersion Program (UDP)

NASA

CEV Heat Shield Gap Analyses





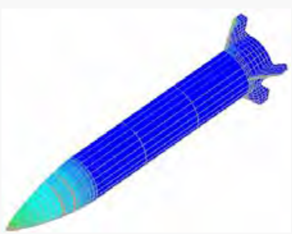
Ablator Gap Seal Flow and Heat Transfer Analyses

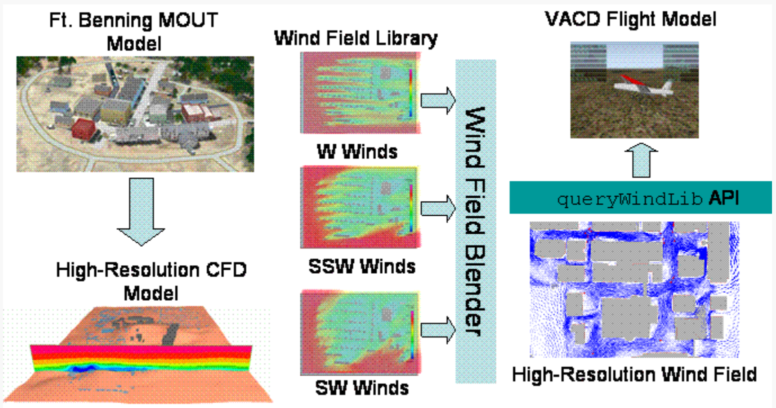
Defense Applications Branch

Mission

Support the DOD, DHS, DoE and Industrial Customers via Technology Transfer of First-Principles Based Scientific Computing Applications and Methodologies

Army	AFRL/VACD	Private Firm
Missile Weather Encounter Modeling Software	**High Resolution Micro-UAV Wind Fields**	**Building Environmental Impact Study**





Couple GCAT output and ATAC Missile Model: Coatings, Ablation, Hydrometeor Impact…

CFD Wind Libraries for use by Micro-UAV Flight Vehicle Models

Determine effect of potential building in Manhattan

CFDRC

WRF + CFD-Urban: Investigate Improved T&D Capability

SBIR Phase I: "*Improved High-Fidelity Forecasting Capability using Combined Mesoscale and Microscale Models*"

- **Tech. Monitor: CDR Stephanie Hamilton**

- **Investigate improvement in T&D accuracy via merging capability of Mesoscale and Microscale Models**
- **Focus upon community models:**
  - **Weather Research and Forecasting Model: WRF**
- **Evaluate Downscale Data Transfer upon CFD-Urban T&D Accuracy:**
  - **Use Urban 2000, IOP 10, Compute Statistical Measures**
    - **Raging Waters Met Station input (baseline)**
    - **WRF Forecast Mode: Noah and Noah/UCM Urban Parameterization Schemes**
- **Investigate Upscale Data Transfer: Compare WRF and CFD-Urban Fields**
- **Demonstrate Operational Concept:**
  - **Cyclical Met Data Ingest using Event-Driven CFD-Urban**

CFD-Urban: Urban Area T&D Model

Computational Fluid Dynamics Modeling for Wind, Turbulence, Transport and Dispersion in Urban Areas

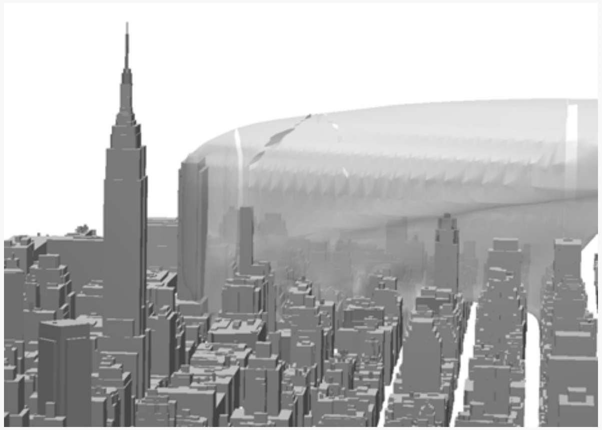
Specialized Model Generation, Setup, Processing

Building Models: GIS, Lidar/imagery, CAD

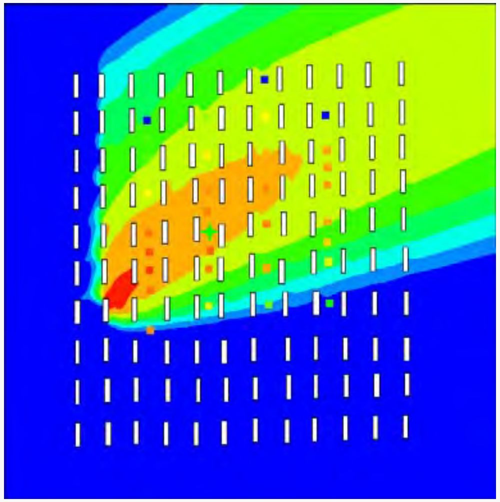
Flow and Turbulence: Steady/Unsteady, RANS, LES

Transport: Eulerian (gases), Lagrangian (particles)

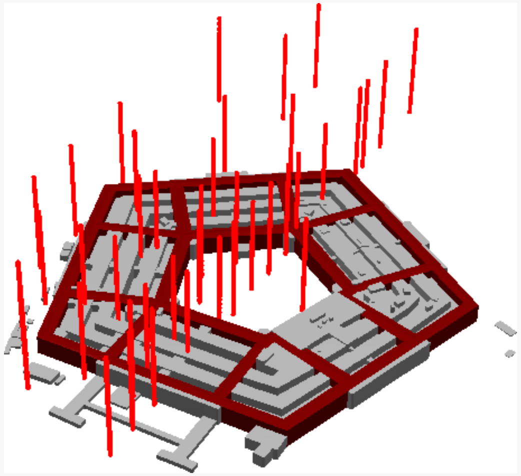
Vertical Mixing, Lateral Spreading, Turbulence Generation



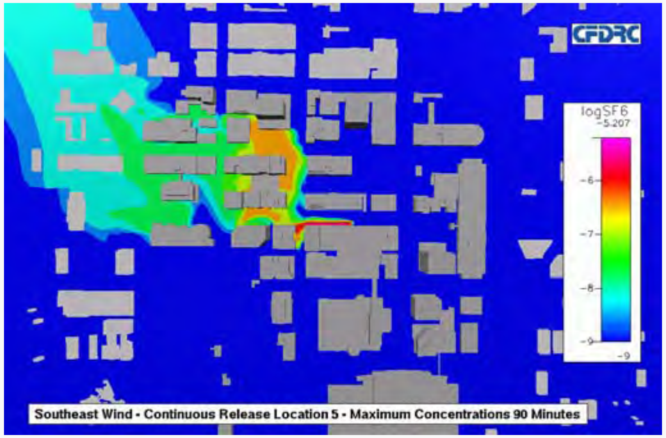
MSG05 and MID05 Support



MUST



Pentagon Shield Model



JU2003 Support

T&D Model Accuracy Characterization: IOP 10 Urban 2000

- Urban 2000: Field Test conducted in Salt Lake City
    - SF6 released in Central Business District
    - Samplers located in CBD and on “arcs” located downstream
    - WRF Forecast Corresponding to IOP 10

•Statistical Comparison of Predicted to Measured Concentration Data on arcs noted

$$FB = \frac{\left(\overline{C_o} - \overline{C_p}\right)}{0.5\left(\overline{C_o} + \overline{C_p}\right)} \qquad MG = \exp\left(\overline{\ln C_o} - \overline{\ln C_p}\right)$$

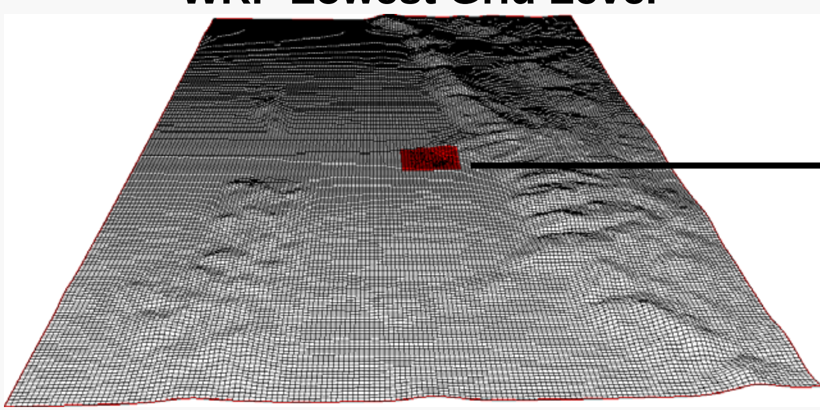
$$NMSE = \frac{\overline{\left(C_o - C_p\right)^2}}{\overline{C_o}\,\overline{C_p}} \qquad FAC2 = \text{fraction of data that satisfy } 0.5 \le \frac{C_p}{C_o} \le 2.0$$

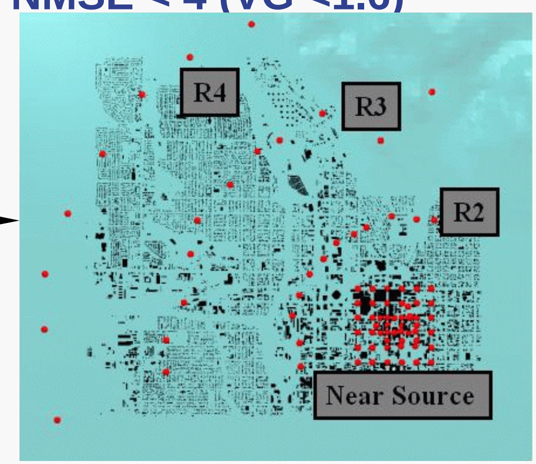
$$VG = \exp\left[\overline{\left(\ln C_o - \ln C_p\right)^2}\right]$$

Acceptable values:

- FAC2 > 0.5
- -0.3 < FB <0.3 (0.7 <MG < 1.3)
- NMSE < 4 (VG <1.6)

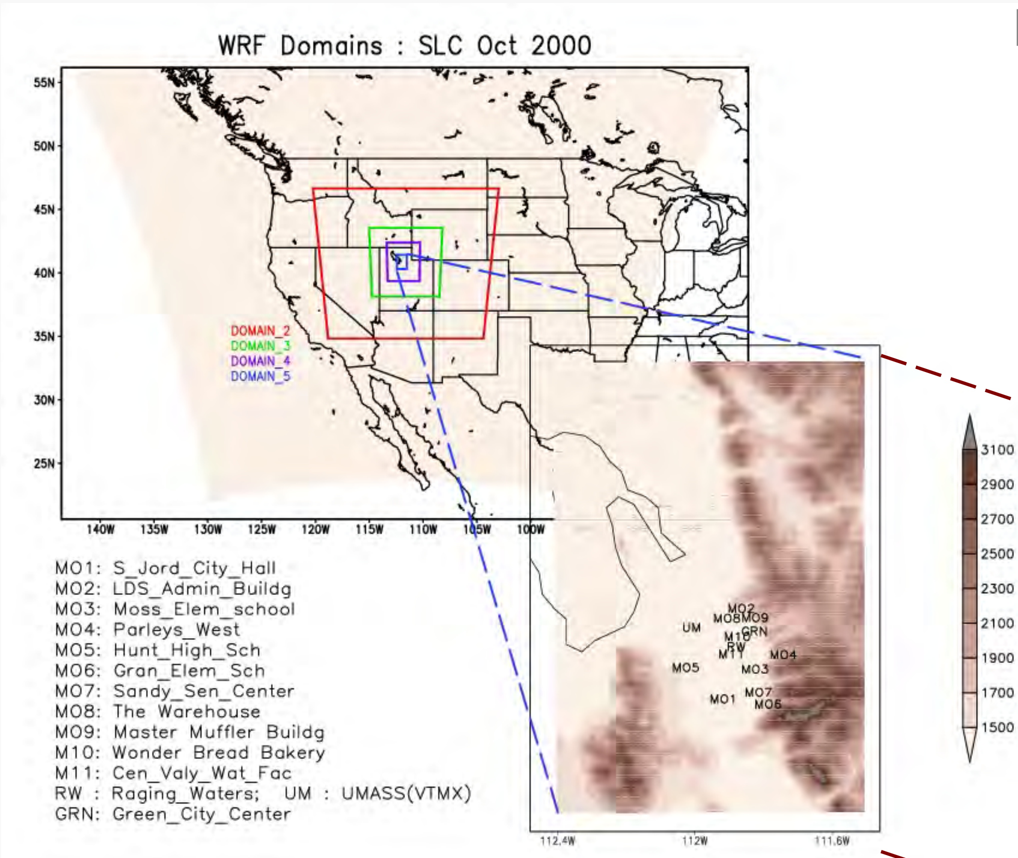
WRF Lowest Grid Level





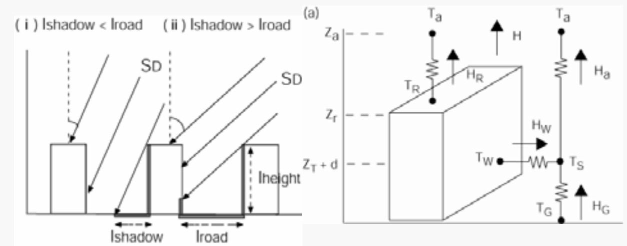
WRF Forecast Model Runs: Urban 2000 IOP 10 Period

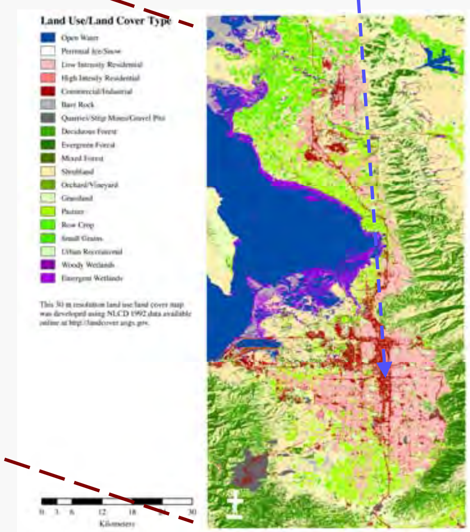
Domains: 40.5,13.5,4.5,1.5,0.5 Km



Complex terrain on WRF nested D-5 (0.5 km grid spacing) over the Salt Lake City area

Single layer Urban Canopy Model





Complex urban land use distribution over SLC

NCAR

WRF to CFD-Urban: Downscale Transfer Procedures

- **Process WRF datasets (NetCDF format):**
  - **Interpolate data to CFD-Urban grid boundary faces**
  - **Continuous, linear interpolant**

$$f_L = \sum_{n=1}^{4} N_n f_n \qquad f_U = \sum_{n=5}^{8} N_n f_n \qquad f(x,y,z) = f_L + (f_U - f_L)\frac{(z - z_L)}{(z_U - z_L)}$$

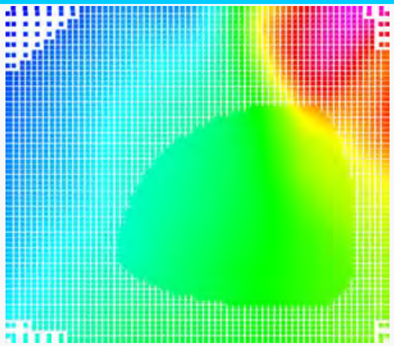
- **Pressure: Remove hydrostatic variation by subtracting ideal atmosphere and imposing base pressure on this "column"**
  - **Allows imposition of lateral pressure gradient from WRF**

$$\Delta P = P_{WRF,G} - P_h = P_{WRF.G} - P_b\left[1 - \frac{1}{\kappa}\frac{g}{RT_b}(z - z_b)\right]^{\kappa}$$

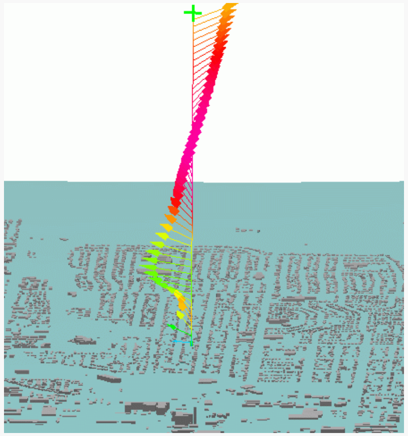
- **Turbulence Field:**
  - **Directly use TKE from the MYJ model ("TKE_MYJ")**
  - **Compute TKE dissipation rate using TKE and momentum diffusion coefficient ("AKM_M")**

$$\varepsilon = \rho C_\mu k^2 / \mu_t$$

Lateral, WRF Imposed Pressure Gradient



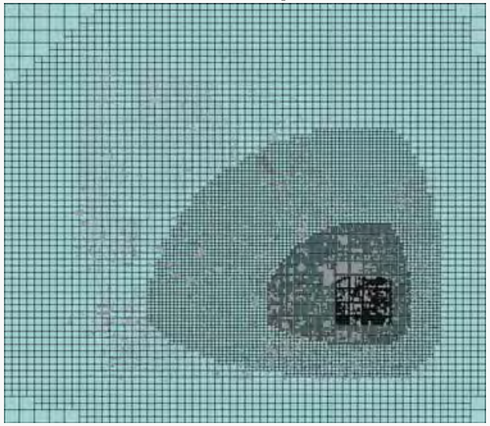
Flow Turning



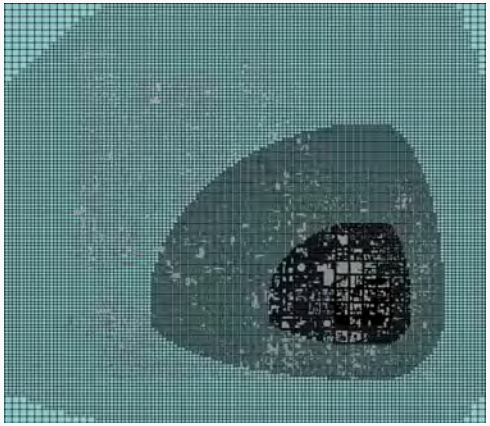
CFD-Urban Model Runs

- Unsteady Mode:
  - Solve Mass, Momentum, Turbulence Model Equations, and Transport Equation unsteady
- Quasi-Steady Mode:
  - Use libraries of equilibrium wind fields computed at different times: 15 minute intervals from WRF output
- Downscale Data Transfer (Boundary Conditions)
  - Isolated Met Station Input: Raging Waters (baseline)
  - WRF/Noah: 15 Minute Intervals
  - WRF/Noah/UCM: 15 Minute Intervals
- Cartesian Adaptive/Prismatic Grids
  - Quadtree in (x,y), Extruded in z
  - High resolution where needed with high grid quality
  - Coarse: 20 to 200 m
  - Fine: 10 to 100 m
  - 8.4 x 7.4 Km Domain

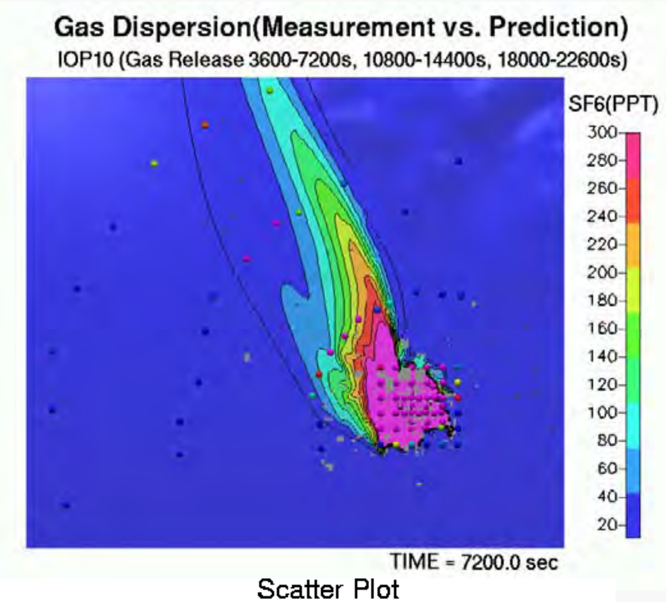
Coarse: 325,000 cells



Fine: 1,300,000 cells

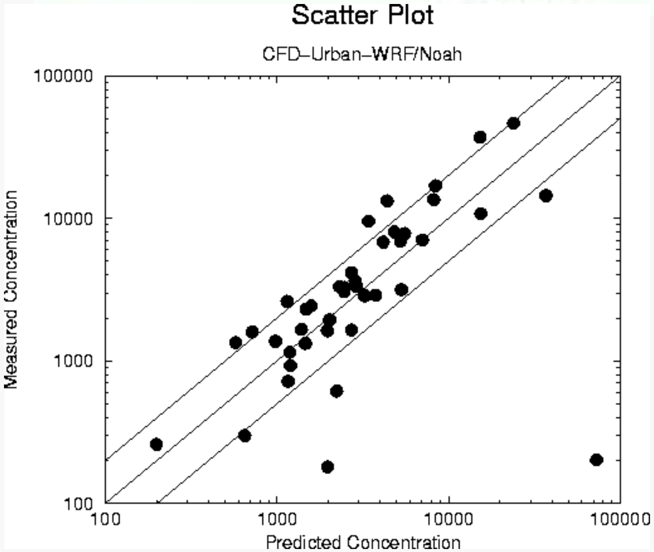


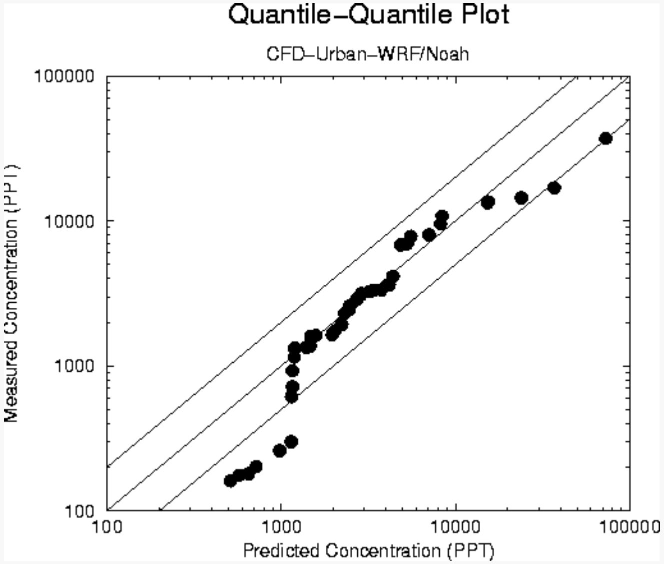
WRF/Noah Downscale: Quasi-Steady, Coarse



Above-to-Ground Level Shear and Plume Travel Direction Changes with Time

	Near Source	*R2*	*R3*	*R4*	*All*
FB	-0.77	0.4	0.8	0.8	-0.76
NMSE	34.36	1	2.3	1.8	53.7
MG	0.74	1.6	2	2.1	1.04
FAC2	0.57	0.4	0.4	0.5	0.51

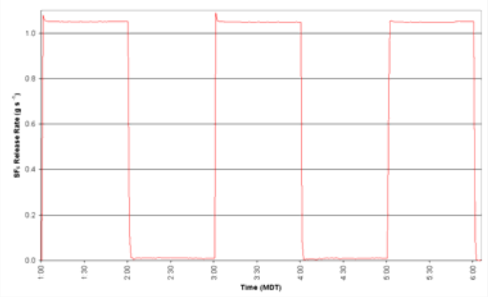




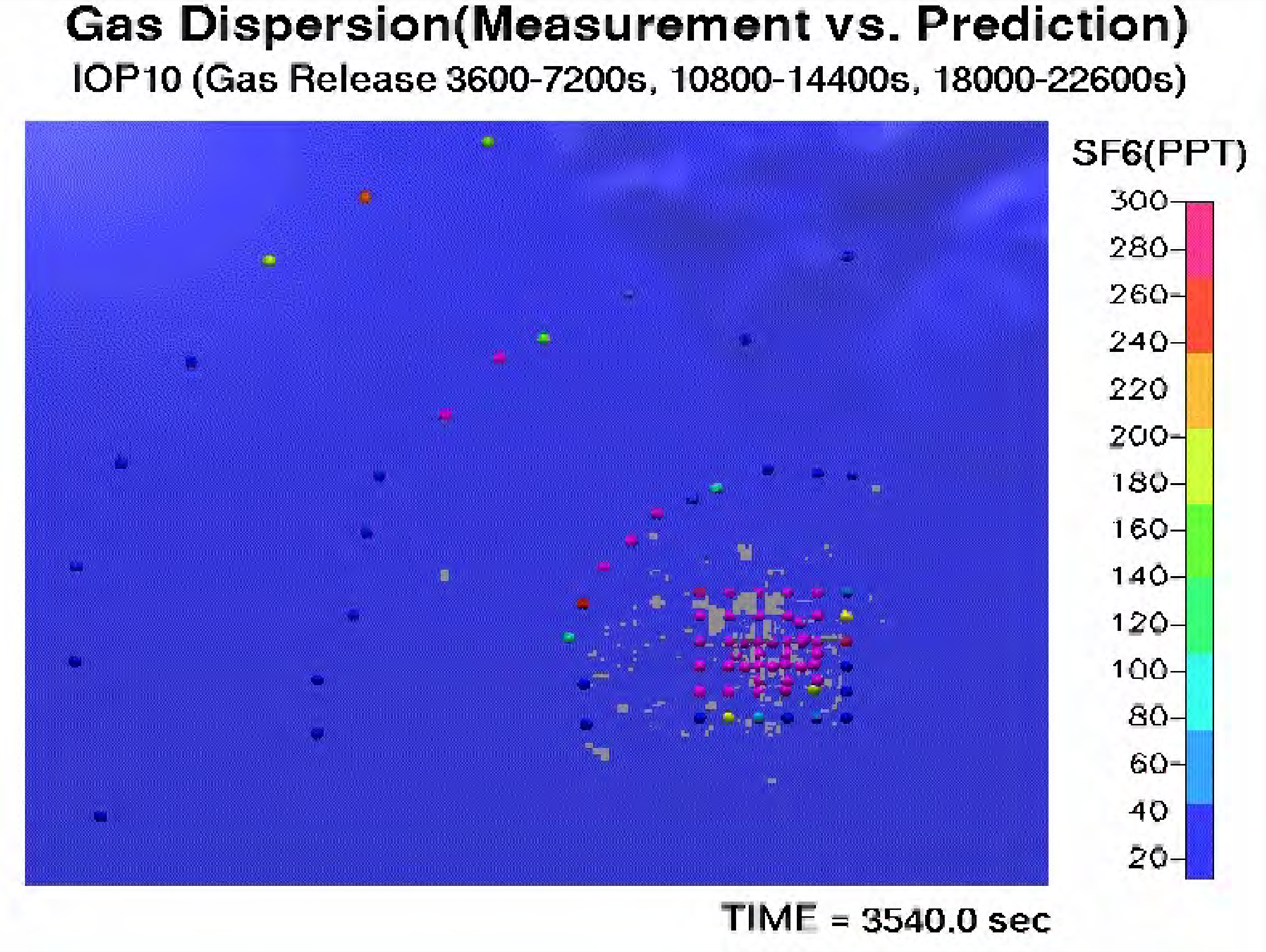
CFDRC

Sample of Results: IOP 10 Urban 2000

- Entire IOP 10
  - 3 Releases/Pauses



- WRF Data for BC
- Quasi-steady approach:
  - Wind/Turbulence fields at 15 minute intervals
  - Unsteady T&D using Unified Frozen Hydro Solver



Summary of Results: IOP 10 Urban 2000

- Three sets of calculations:
  - Raging Waters Input: Use sounding data (single sounding) at all boundary faces
  - WRF Downscale Data Transfer: Unsteady Flow, Turbulence and Contaminant
  - WRF Downscale Data Transfer : Quasi-Steady Flow ("Wind Library"), Frozen Hydro Contaminant Transport

	Near Source	R2	R3	R4	All
FAC2: RW	0.12	0.17	0.36	0.38	0.18
FAC2: Unsteady	0.08	0.17	0.36	0.38	0.16
FAC2: Quasi-Unsteady	0.57	0.42	0.36	0.5	0.51
MG: RW	25.42	14.11	4.58	5.06	15.83
MG: Unsteady	15.89	11.64	4.77	5.679	11.69
MG: Quasi-Unsteady	0.74	1.59	1.96	2.05	1.04

- Quasi-Steady approach appears to be best mode of operation:
  - Steady-state wind/turbulence fields at set intervals in time using WRF data as boundary conditions: Library of Wind Fields
  - Use Unified Frozen Hydrodynamics Approach for T&D
- Unsteady flow/turbulence/transport: Time step restrictions
  - Too costly for accuracy or inaccurate because time step is too big

Pentagon Shield CFD Component: Operational Concept

Startup

Initialization

Met Ingest

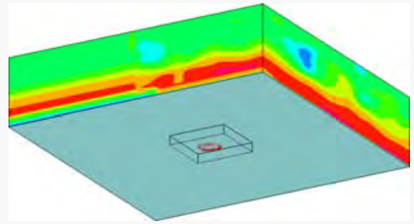
Flowfield Solve

Data Storage

Building Pressures

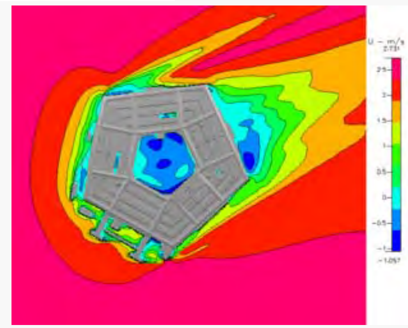
Gridded Output

C
Y
C
L
E



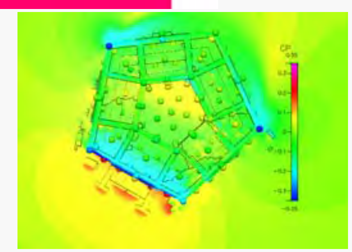
Ingest Gridded Met Data Set

Apply as Boundary Conditions



Flow+Turbulence

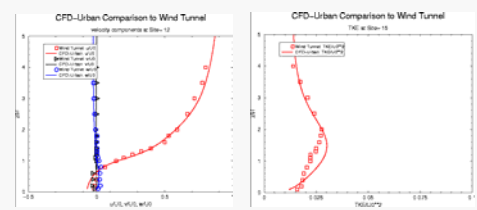
Solve



Building

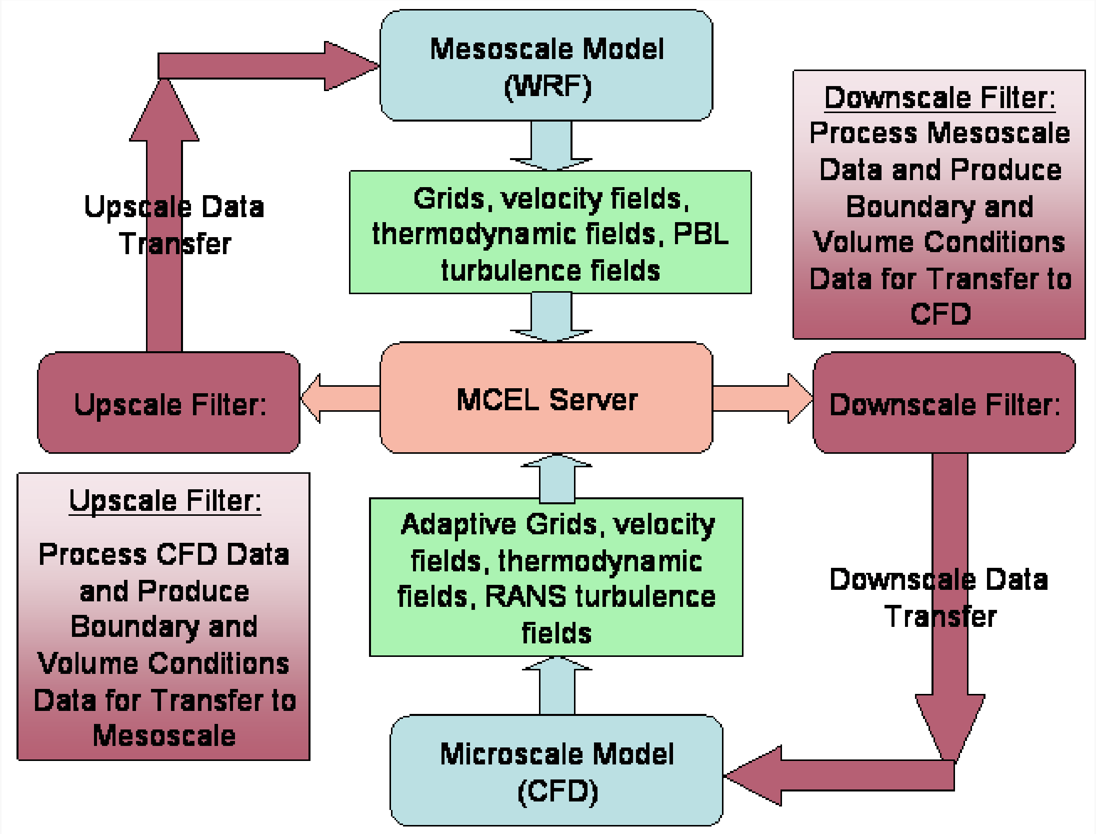
Pressures

Velocity and
Turbulence
Fields



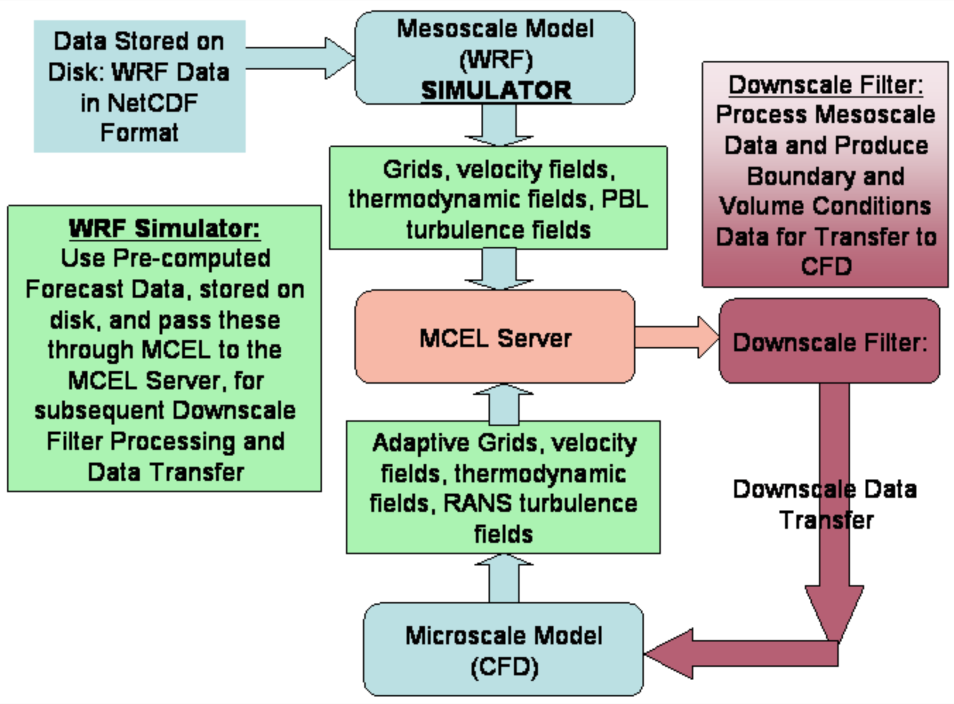
"Merged" CFD and Mesoscale Model Concept

- Model Coupling Environmental Library (MCEL) to couple:
    - Weather Research and Forecasting (WRF) Model
    - Specialized Urban CFD Model
- MCEL is a dataflow based model:
    - Models send data to the MCEL Server
    - Filters "Pull" data from servers and manipulate it
- MCEL is based upon using CORBA:
    - Client/Server design allows all components to operate relatively independently
    - Heterogeneous environments



“Merged” CFD and Mesoscale Model Concept

- **Downscale Filter:**
  - **Pulls “WRF” data from the MCEL server and “downscales” the data for use as applying boundary conditions to the CFD solver**
- **“WRF Simulator”: Simulates WRF being in the loop and pushes data to the server using WRF native data formats (netCDF)**
  - **MCEL data caching capability being investigated for this purpose**

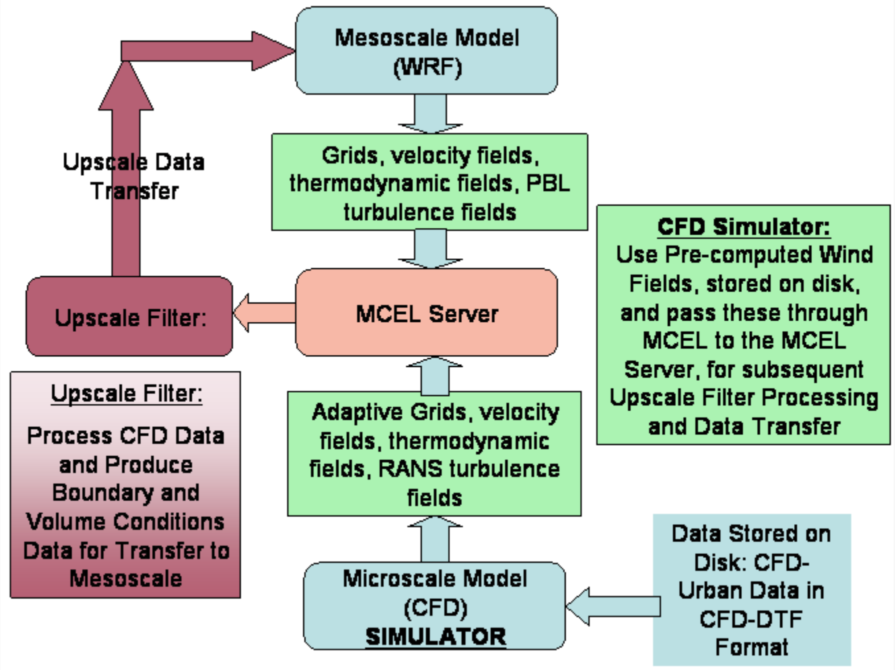


Downscaling:

- **Interpolate WRF velocity and turbulence fields onto CFD mesh**
- **Downscale “filter” pulls MCEL data from server, interpolates onto CFD mesh**
- **Uses “sub-cube” of finest nest**

“Merged” CFD and Mesoscale Model Concept

- Upscale Filter:
  - Pulls “CFD” data from the MCEL server and “upscales” the data for use in WRF
  - Debating what to upscale, but consensus appears to be volumetric data
- “CFD Simulator”:Simulates CFD being in the loop and pushes data to the server using CFD native data formats (CFD-DTF)
  - MCEL data caching capability being investigated for this purpose

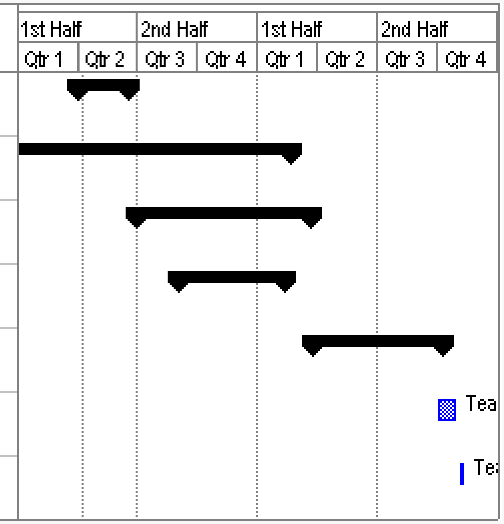


Upscaling:

- Compute momentum flux-integral for all cells contained within (coarser) WRF cells
- “Decimation” produces body force tendency, replaces drag terms from urban canopy model
- Uses “sub-cube” of finest nest

Schedule and Work Plan

ID	Task Name	Duration	Work	Start	Resource Names
1	**Task 1: Develop WRF-MCEL-CFD Integration Framework and Protocols**	**54 days**	**712 hrs**	**Tue 1/2/07**	
7	**Task 2: CFD Model Development**	**309 days**	**1,808 hrs**	**Tue 9/5/06**	
12	**Task 3: Microscale Model Integration**	**185 days**	**960 hrs**	**Mon 4/2/07**	
17	**Task 4: Mesoscale Model Integration**	**115 days**	**920 hrs**	**Mon 6/4/07**	
22	**Task 5: WRF-MCEL-CFD Model Test and Evaluate**	**140 days**	**1,120 hrs**	**Mon 12/24/07**	
26	Task 6: Documentation and Installation Procedures	20 days	160 hrs	Mon 6/30/08	Team
27	Task 7: Final Report and Briefings	5 days	40 hrs	Mon 8/4/08	Team



Task 1: Upscale/Downscale Data and Protocols are being defined (delays getting all contracts/subcontracts in place)

Task 2: New, specialized solver and system under development

Task 3: Not yet begun

Task 4: Not yet begun

Task 5: Not yet begun

Task 6: Not yet begun

Specialized CFD Solver and Related Development

- Upgrade mesh generation, numerics and parallel processing software to permit faster processing rates and higher fidelity physics:
  - Mesh Generation:
    - Cartesian Adaptive grids combined with Virtual Cell Embedding and cell-based Porosity for sub-cell resolution of features
  - Numerics:
    - Low-Mach Number Pre-Conditioned, Reynolds-Averaged Navier-Stokes Equations
    - Coupled mass+momentum+energy more suitable for atmospheric flows
  - Parallel Processing Software
    - Maximal use of the PETSc (Portable Extensible Toolkit for Scientific Computing) library
    - System of Non-Linear Equation Solvers (SNES) framework
      - Newton-Krylov-Schwarz parallel, implicit

“Feed the PETSc engine”

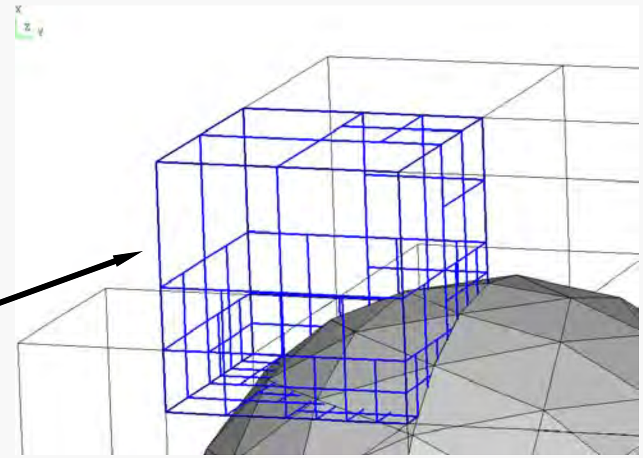
Technical Progress to date: AMR_VCE

- Adaptive Mesh Refinement Virtual Cell Embedding: AMR_VCE
- Solution adaptive Cartesian mesh using hierarchical (octree) system
    - Based upon HAMR classes and techniques
- Triangulated surface queries and tools using the GNU Triangulated Surface Library (GTS)
- Basic Algorithm:
    - Refine mesh where cells are "cut" by body (in/out) until a given level of refinement
    - Take each cell and "virtually" refine it near the boundary until a given level of (much finer) refinement
    - Use the geometric information of the adaptively refined "virtually embedded cell" to obtain approximations to the boundary to be represented in the larger "parent" cell
    - Insure Geometric Conservation Law consistency during construction of the cut cell centroids, integration points etc.
    - An "Adaptive Mesh Refinement" refinement of VCE [Landsbury, Boris]

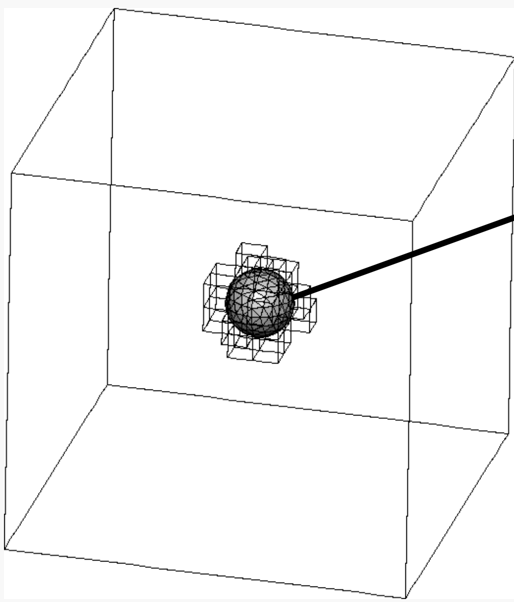
Technical Progress to date: AMR_VCE

- **Example: Sphere (represented via STL)**

Single AMR_VCE Cell (blue)



VCE Cells Boundaries

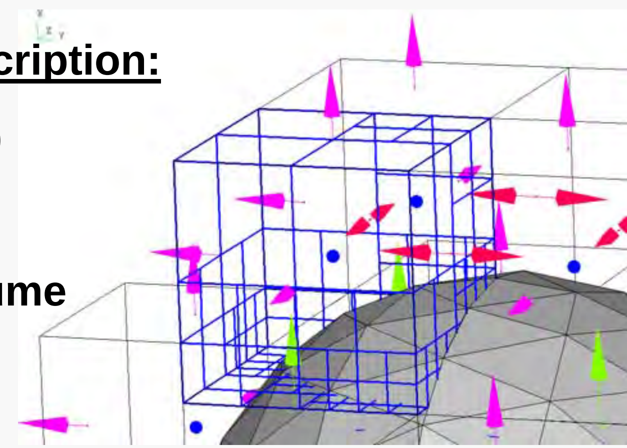


<u>"Cut" Cell Geometric Description:</u>

Cut Cartesian Faces (CCF)

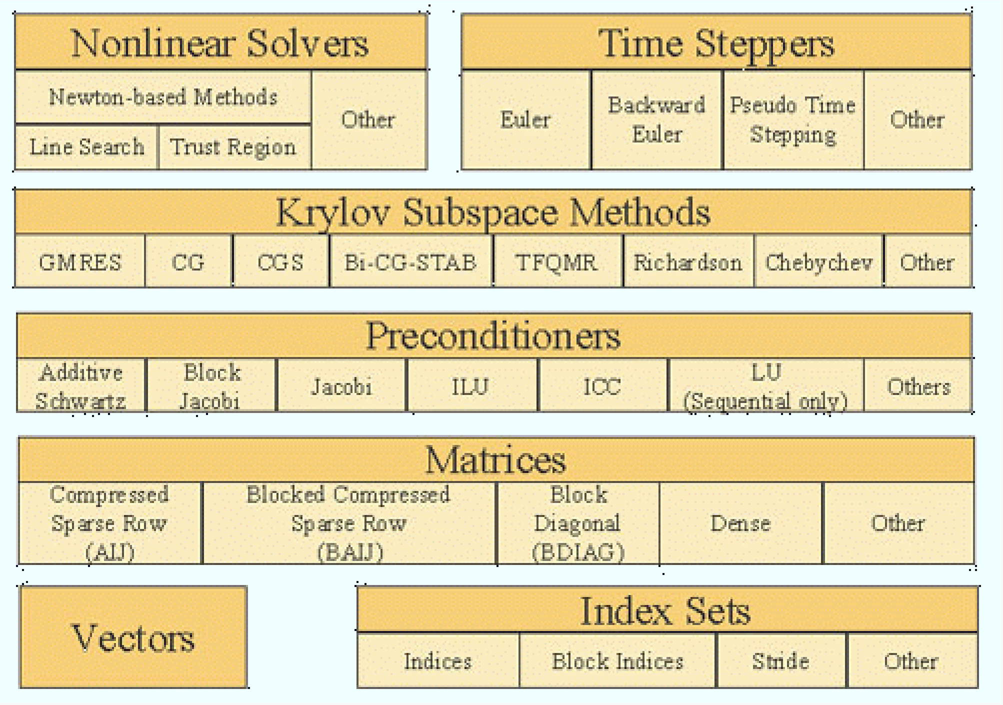
Cut Face

Cut Cell Centroid and Volume



Technical Progress to date: Flow Solver Technology

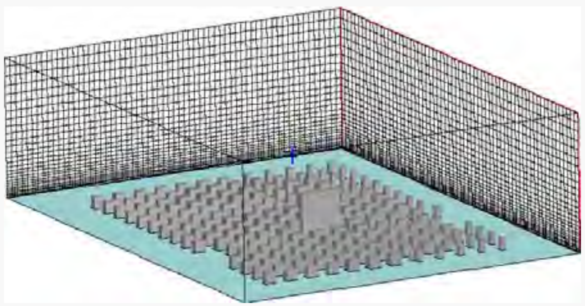
- Evaluation and Testing of PETSc
- Parallel Extensible Toolkit for Scientific Computation (PETSc)
  - Developed by Argonne National Labs for parallel solution of sparse matrices encountered in scientific computing.
  - Becoming a very widely used application

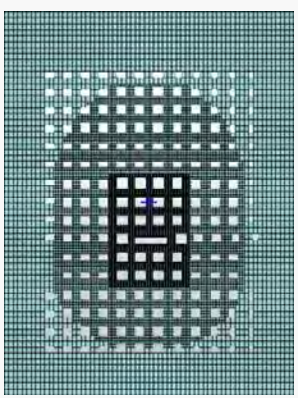


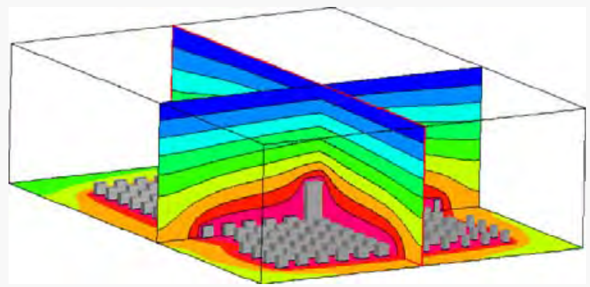
- Parallel computing framework using basic "classes" supported in the PETSc library
- Provides large variety of Krylov-based solvers and matrix preconditioners, all in parallel.
- Proven to be very efficient and scalable.
- Choices of use:
  - Develop as usual, retrofit PETSc
  - Design from start to use PETSc

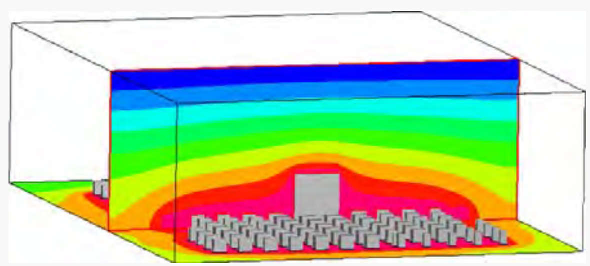
Technical Progress to date: Flow Solver Technology

- “Iterative” Approach to developing the PETSc-specialized flow solver:
  - Laplace Equation solver: Serial, Parallel
  - Euler Equation Solver: Parallel, low-Mach Number Preconditioned
  - RANS Solver: Add viscous terms and 2-equation Turbulence Model (kε or MYJ)









Boundary Conditions:

- u=1 on Buildings
- u=0 on “Sky” boundary
- Zero gradient on all others
- 380,000 unknowns
- 2.4M matrix elements

Flow Solver Technology: Low Mach Preconditioning

- **Low-Mach Number Preconditioning Approach: [Weiss, et al., 1995, Merkle, et al., 1996]**
  - **Fully-coupled mass, momentum and energy equations, "Compressible" formulation**
  - **Preconditioning removes stiffness of equations as Mach number approach zero**

$$\frac{\partial}{\partial t}\iiint W dV + \iint [F - G] \bullet dA = 0$$

Conservation Law Form, Conserved Variables

$$\kappa(\lambda) \approx \frac{\lambda_{\max} - \lambda_{\min}}{(\lambda_{\max} + \lambda_{\min})/2}$$

Condition number of hyperbolic system is directly related to the eigenvalues

$$\left(K\frac{\partial W}{\partial Q}\right)\frac{\partial}{\partial t}\iiint Q dV + K\iint [F - G] \bullet dA = 0$$

Primitive Variables, Pre-multiply by preconditioning matrix, K (not in conservative form now…)

$$K\frac{\partial W}{\partial Q} = \begin{pmatrix} \rho_P & 0 & 0 & 0 & \rho_T \\ 0 & \rho & 0 & 0 & 0 \\ 0 & 0 & \rho & 0 & 0 \\ 0 & 0 & 0 & \rho & 0 \\ -1 & 0 & 0 & 0 & \rho C_P \end{pmatrix}$$

Note that terms pre-multiplying density time derivate approach zero as the Mach number approaches zero, decoupling mass from the other equations.

$$\kappa(\lambda) \approx \frac{1}{M}$$

Flow Solver Technology: Low Mach Preconditioning

$$\Gamma \frac{\partial}{\partial t}\iiint Q\,dV + \iint [F - G] \bullet dA = 0$$

Conservation Law Form, Primitive Variables, pre-conditioned equations

$$\Gamma = \left(K^{-1}\Gamma_{nc}\right) = \begin{pmatrix} \Theta & 0 & 0 & 0 & \rho_T \\ \Theta v_x & \rho & 0 & 0 & \rho_T v_x \\ \Theta v_y & 0 & \rho & 0 & \rho_T v_y \\ \Theta v_z & 0 & 0 & \rho & \rho_T v_z \\ \Theta H - 1 & \rho v_x & \rho v_y & \rho v_z & \rho_T H + \rho C_P \end{pmatrix}$$

Low-Mach Number Preconditioning replaces "true" EOS derivatives with modified forms that removes the stiffness of the equations:

$$\Theta = \left(\frac{1}{U_r^2} - \frac{\rho_T}{\rho C_P}\right) \qquad U_r = \begin{cases} \varepsilon c, & if \quad |v| < \varepsilon c \\ |v|, & if \quad \varepsilon c < |v| < c \\ c, & if \quad |v| > c \end{cases}$$

- **System of equations now remains well conditioned at all speeds and for all EOS**

$$u = v.\hat{n} \quad u' = u(1-\alpha) \quad \alpha = \left(1 - \beta U_r^2\right)/2 \quad c' = \sqrt{\alpha^2 u^2 + U_r^2}$$

$$\lambda\left(\Gamma^{-1}\frac{\partial F}{\partial Q}\right) = u, u, u, u'+c', u'-c'$$

$$\kappa(\lambda) \approx \frac{\sqrt{\alpha^2 + (U_r/u)^2}}{(1-\alpha)}$$

- **Compressible** $\kappa(\lambda) \approx \frac{1}{M}$
- **Compressible, Low Mach** $\kappa(\lambda) \approx 1$
- **Incompressible** $\kappa(\lambda) \approx 1$

Flow Solver Technology: Low Mach Preconditioning

$$\Gamma \frac{\partial \tilde{Q}}{\partial t} \Delta V + \sum_{faces} \left[\tilde{F} - \tilde{G} \right] A_{face} = 0$$

Discrete, Conservative Form, Primitive Variables, Pre-conditioned System

$$F = \frac{1}{2}\left(F_L + F_R\right) - \frac{1}{2}\left|A\right| \Delta W$$

$$\left|A\right| \Delta W \cong A \Delta W = \Gamma \left|A_\Gamma\right| \Delta Q$$

Upwind (Hyperbolic Systems) Form

Roe's FDS or Central differencing with 4-th order dissipation using preconditioned hyperbolic system Eigenvalues and Eigenvectors

("Speed" vs "Accuracy": Who will win?)

- **Use Newton-Krylov-Schwarz Approach to solve the discrete, preconditioned equations:**
  - **Proven scalability and high-performance using the PETSc suite**
  - **Similar techniques as PETSc-FUN3D, which won the 1999 Gordon Bell Award**

$$\left[\frac{\Gamma}{\Delta t} - \frac{\partial R}{\partial Q} \right] \Delta Q = R(Q)$$

$$CFL^N = CFL^{N-1} \left(\frac{\left\| f^{N-1} \right\|}{\left\| f^N \right\|} \right)^\beta$$

Technical Progress to date: Flow Solver Technology

- **Developing flow solver from the ground up to be PETSc compliant**
- **Using lessons learned from many different unstructured flow solvers, parallel processing studies:**
  - **Interleaved data structures, ordering of unknowns and visitation order (coloring)**
  - **Reduction in cache misses, communication patterns, line-search strategies…**
- **Use the PETSc SNES to solve the parallel system of equations:**
  - **Provide 2 functions called by SNES solver:**
    - **Residual evaluation and Jacobian evaluation**

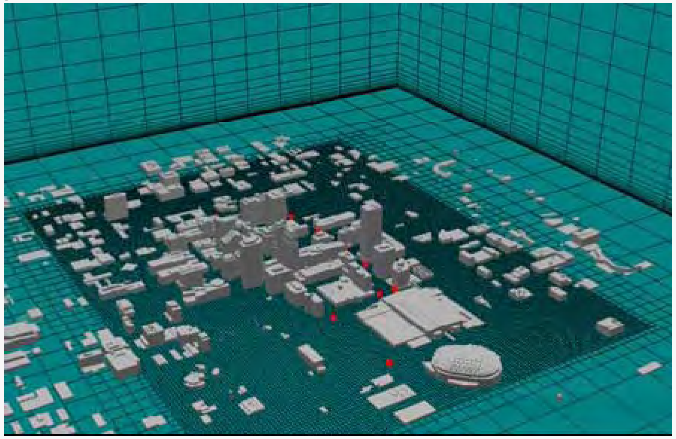
```
SNESCreate(MPI_COMM_WORLD,&snes);

SNESSetType(snes,"ls");

SNESSetFunction(snes,pData->rhs,formFunction,PETSC_NULL);

MatCreateMPIBAIJ(PETSC_COMM_WORLD,bs,m,n,M,N,&d_nnz,d_nz,o_nnz,o_nz, &J)

SNESSetJacobian(snes,J,J,formJacobian,PETSC_NULL);
```

```
SNESGetKSP(snes,&ksp);

KSPSetType(ksp,KSPBCGSL);

SNESSetTolerances(snes,1.0e-10,1.0e-10,1.0e-40,10000,10000);

KSPSetTolerances(ksp,1.e-10,1.e-10,1e+50,100);

SNESSolve(snes,PETSC_NULL,pData->sol);
```

FEED THE PETSc SNES SOLVER

Technical Progress to date: Flow Solver Technology

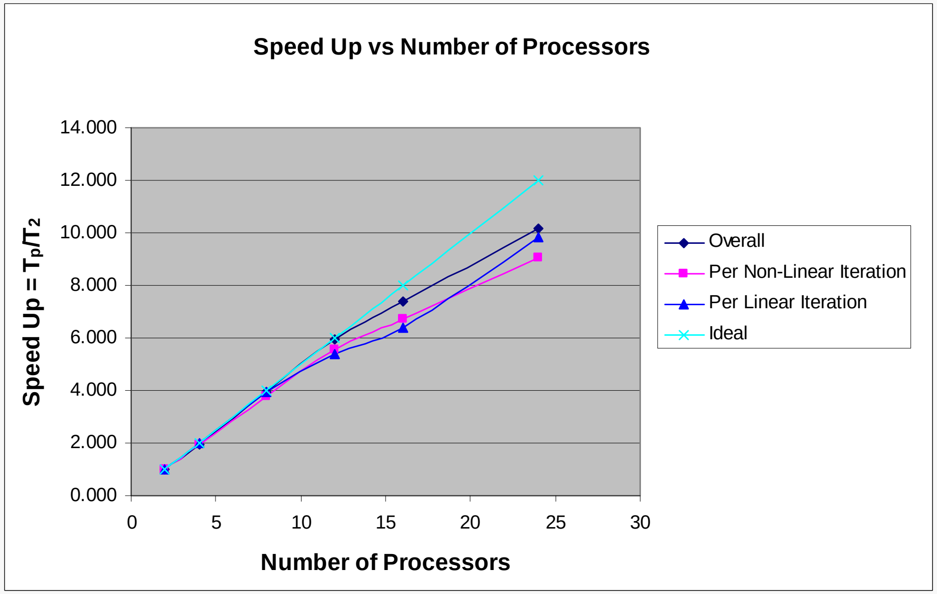
- **Scalability study: Euler equations, non-preconditioned**

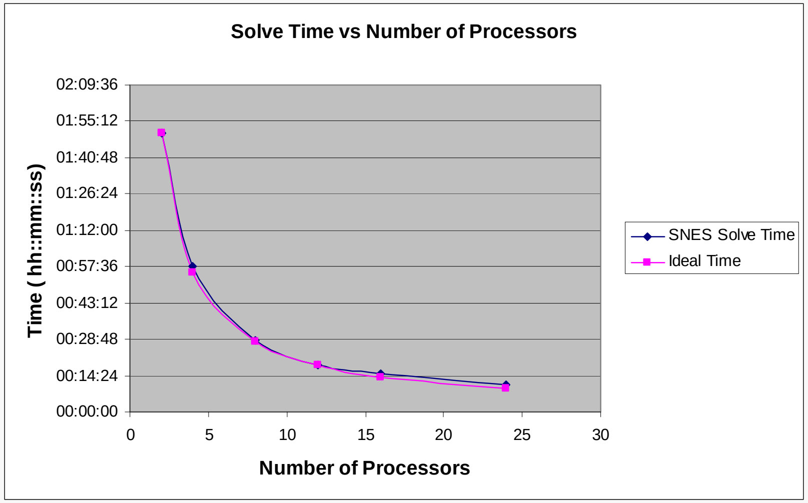


Case 1: Oklahoma City CBD Grid generated by CFD-Urban

- **175,000 cells**

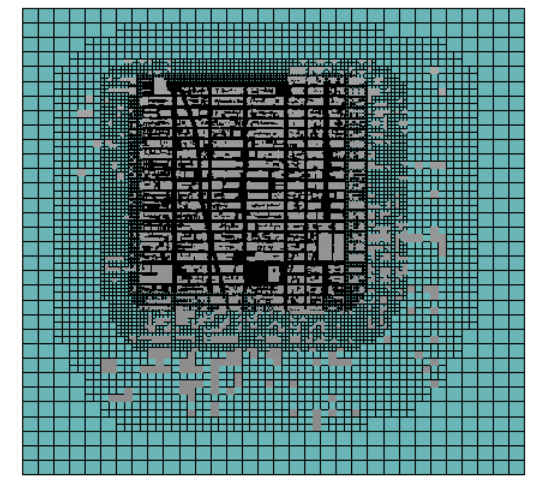
•Linear Solver: BiCGSTAB*(l)*, Preconditioner: Block Jacobi, ILU on each block.





Tail-off after 12 processors due to using dual processors(!)

Technical Progress to date: Flow Solver Technology

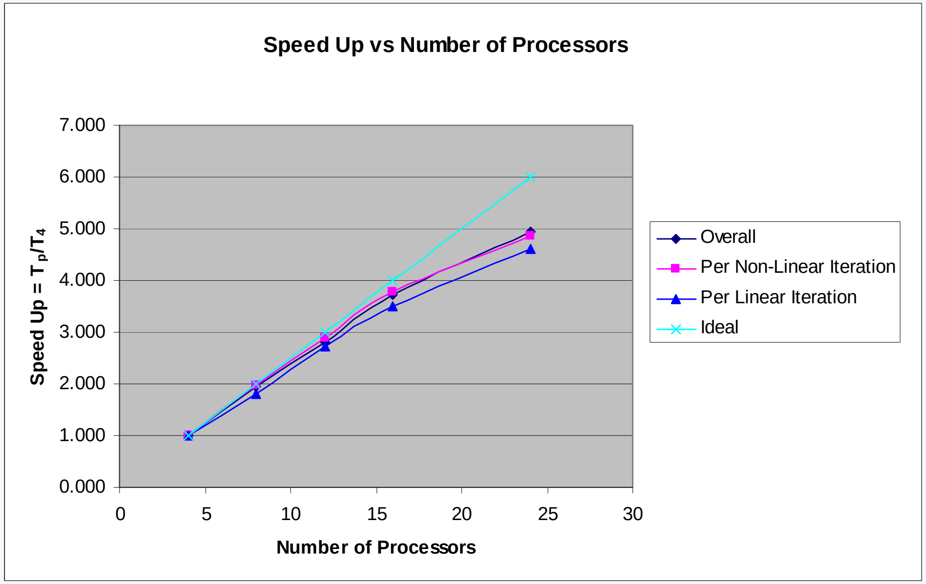


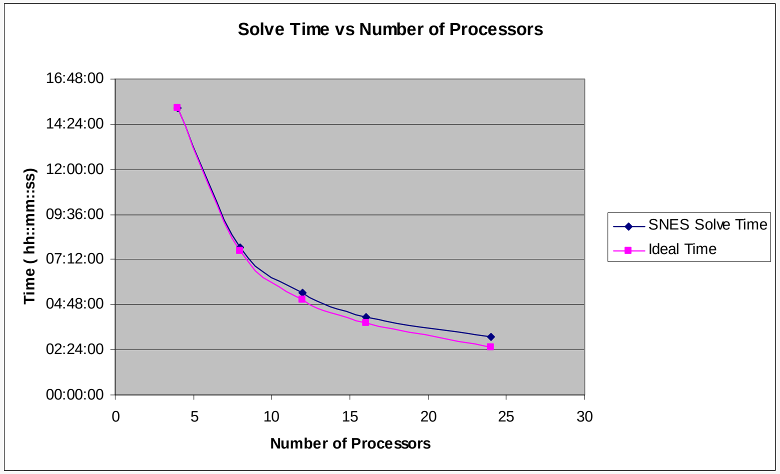
- Scalability study: Euler equations, non-preconditioned

Case 2: Midtown Manhattan Grid generated by CFD-Urban

- **1,460,000 cells**

- **Linear Solver: BiCGSTAB*(l)*, Preconditioner: Block Jacobi, ILU on each block.**

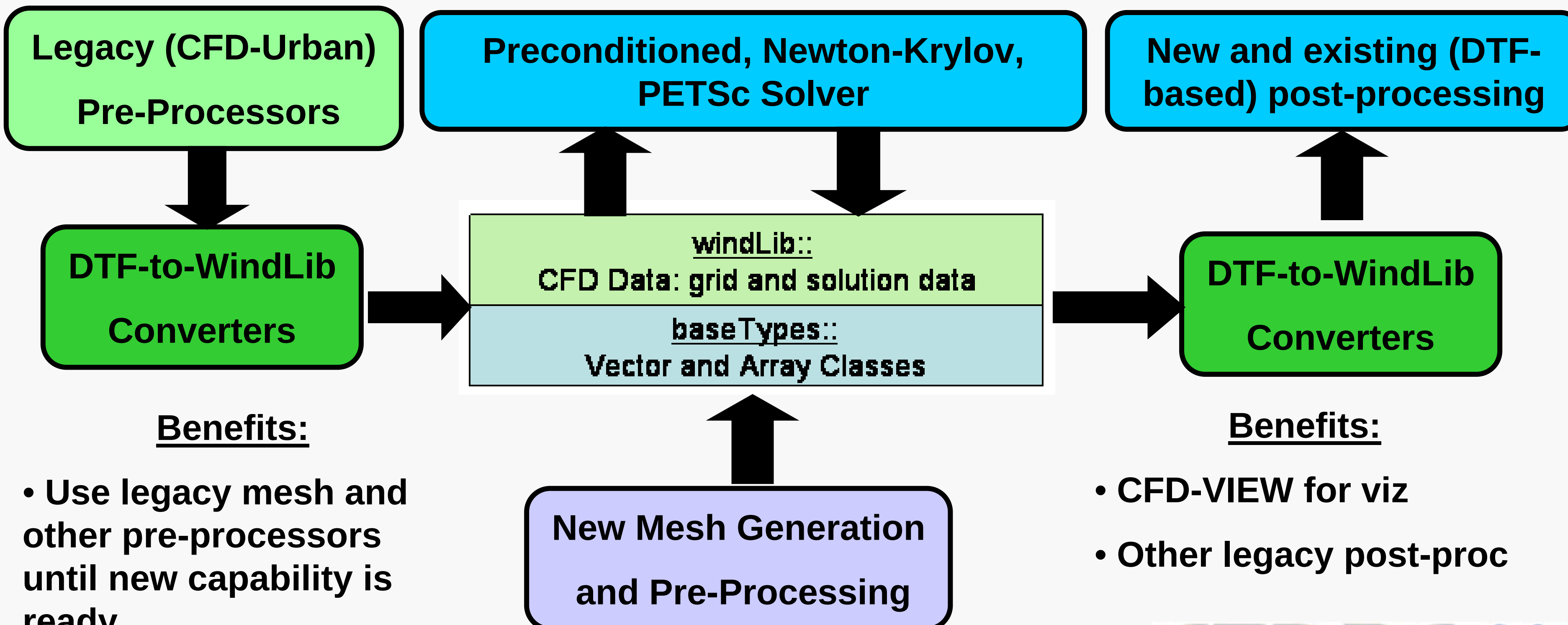




Tail-off after 12 processors due to using dual processors(!)

Wind Library Database API and Classes

- C++ classes/namespaces devoted to storage and access of grids and solution data
- Move away from ESI (ex-CFDRC) proprietary CFD-DTF and related libraries
- baseTypes:: derived from std namespace vector<T>
- windLib:: hierarchical data structures stored using simple strings and disk access



Benefits:

- Use legacy mesh and other pre-processors until new capability is ready

Benefits:

- CFD-VIEW for viz
- Other legacy post-proc

Conclusions and Plans

• Beginning to work with MCEL, downscale/upscale filters

• Flow solver development is proceeding according to plan

• If all goes according to plan: Will be coupled this time next year

2007 Chemical Biological Information Systems (CBIS) Conference & Exhibition

Supported by:

Joint Project Manager Information Systems (JPM IS)
And Joint Science & Technology Office (JSTO)

January 8 - 11, 2007 ~ Austin, TX
Renaissance Austin Hotel
Event #7320

Conference Announcement: Chemical and Biological Information Systems (CBIS 2007) Conference, hosted by National Defense Industial Association and Supported by The Joint Science & Technology Office, Joint Project Manager Information Systems and the JPEO-CBD at the Renaissance Austin Hotel, in Austin, Texas on January 8 - 11 2007. This unclassified conference will include discussions in the areas of innovative technologies, concepts, and applications that can be applied to current and future Chemical and Biological Information Systems.

The continuing proliferation of chemical and biological weapons and associated capabilities has broadened the range of scenarios in which potential use of these weapons against U.S. Forces is possible. The challenge to government, academia, and industry is to deliver revolutionary science and technology results that will protect the warfighter from the effects of chemical and biological weapons. To meet these challenges, participation by industry, academia, government and international personnel is encouraged.

Conference Overview and Objectives: As evolutionary, or “enhancement” technologies and incremental scientific advances are not achieving many of the needed advances in warfighting and defense capabilities, this conference is intended to foster creative “out of the box” thinking. Further, the objective of this conference is to provide a global forum for the exchange of information, ideas, and methodologies to eliminate chemical and biological threats to the warfighter. We are seeking revolutionary science and technology which will result in demonstrable success improving Chemical and Biological Information Systems.

Monday, January 8, 2007

Noon – 4:30PM	Exhibitor and Poster Move-in
3:00PM – 6:30PM	Registration
5:00PM – 6:30PM	Exhibits open (Light Reception)

Tuesday, January 9, 2007

PLENARY SESSION CHAIR: Mr. Charles Fromer, Conference Chair, Joint Science and Technology **Office, Chem-Bio Defense Programs**

7:00AM – 8:00AM	Continental Breakfast and Onsite Registration
8:00AM – 8:15AM	Welcome and Introduction – Mr. Charles Fromer, Conference Chair, Joint Science and Technology Office, Chem-Bio Defense Programs
8:15AM – 8:45AM	Keynote – COL Ben Hagar, USA, Deputy Director, Joint Science and Technology Office, Defense Threat Reduction Agency
8:45AM – 9:15AM	Keynote – Mr. Doug Bryce, Deputy, Joint Program Executive Office, Chemical and Biological Defense
9:15AM – 9:45AM	Keynote – Mr. Jean Reed, Special Assistant to the Secretary of Defense for Chemical and Biological Defense Programs
9:45AM – 10:30AM	BREAK (Exhibit Area)
10:30AM – 11:00AM	Future programs: JPEO Overview
11:00AM – 11:30AM	Joint Project Manager Information Systems: Program Overview
11:30AM – 1:00PM	Lunch (Exhibit Hall Closed for lunch)
1:00PM – 1:35PM	Joint Effects Model: Program Overview and Status
1:35PM – 2:10PM	Joint Operational Effects Federation: Program Status
2:10PM – 2:45PM	Joint Warning and Reporting Network: Program Overview and Status
2:45PM – 3:30PM	Joint Project Manager Information Systems: Integration Status

3:30PM – 4:00PM BREAK (Exhbit Area)

4:00PM – 4:15PM Threat Agent Science Capability Area Overview
4:15PM – 4:30PM Information Systems Science & Technology (IS S&T) Capability Area Overview

4:30PM – 5:30PM IS S&T Thrust Areas: Overview

5:30PM – 7:00PM Reception – Exhibit Area (Cash bar & Light Reception)

Wednesday, January 10, 2007

8:00AM – 8:30AM Continental Breakfast and Registration

8:30AM – 8:45AM Session Chairs–Administrative Remarks

8:45AM **BREAKOUT SESSIONS BEGIN**

Hazard and Environmental Modeling – Trinity Room A & B
Session Chair: Mr. Rick Fry, JSTO

Time	Author	Title
8:45AM – 9:15AM	Dr. Todd H. Pierce, SAIC	DTRA Weapon-on-Target Chem-Bio Warfare Facilities Source Model
9:15AM – 9:45AM	Professor Theo G. Theofanous, University of California, Santa Barbara	The Physics of Aerobreakup: Viscous and Viscoelastic Liquids
9:45AM – 10:15AM	Dr. Ashok J. Gadgil, LBNL	Cfd Simulation of Mixed Convection Flows in an Atrium: Comparison of Predictions with Experiments

Data Assimilation and Tactical Applications – Pecos Room
Session Chair: Dr. John Hannan, JSTO

Time	Author	Title
8:45AM – 9:15AM	Mr. Robert I. Sykes, L3–Titan	Source Estimation using Sensor Data and Reverse Transport
9:15AM – 9:45AM	Dr Veronica Rapley, DSTL	Chem-Bio Source Term Estimation
9:45AM – 10:15AM	Mr. Luwi Oluwole, Aerodyne Research, Inc.	SCIPUFF Adjoint Model for Release Source Location from Observational Data

Battle Management – Sabine Room
Session Chair: Mr. William Ginley, ECBC

Time	Author	Title
8:45AM – 9:15AM	Mr. Ric Jones, DTRA	IWMDT
9:15AM – 9:45AM	Mr. Jim Reilly, AFRL	Next Generation Chem Bio Battle Management System–Integrated Information Management System (IIMS)
9:45AM – 10:15AM	Mr. Kevin Grottle, ENSCO, Inc	CBRN Operations Support: Automated Command and Control enabled Sensor Monitoring for Mitigation and Response

Data and Decision Support Tools – San Marcos Room
Session Chairs: Mr. Eric Lowenstein & Ms. Jessica Miller, JSTO

Time	Author	Title
8:45AM – 9:15AM	Dr. Don A. Lloyd, Institute for Defense Analyses	IDA Report on the Modeling & Simulation Roadmap for JSTO-Chem-Bio Data
9:15AM – 9:45AM	Mr. Eric J. Lowenstein, Joint S&T Office for CB Defense	Chem-Bio Data Backbone
9:45AM – 10:15AM	Mr. Scott D. Kothenbeutel, Battelle	Chem-Bio Common Knowledge Base within the GIG

Medical Modeling – San Antonio Room
Session Chair: Ms. Angel Fitzgerald, JSTO

Time	Author	Title
8:45AM – 9:15AM	Dr. William M. Tepfenhart, Monmouth University	Use of a Markov Chain Model for Epidemics
9:15AM – 9:45AM	Dr. Oliver Lanning, Defence Science and Technology Laboratory	Modeling Medical and Operational Effects of CBRN Usage
9:45AM – 10:15AM	Dr. Gene E. McClellan, Applied Research Associates, Inc.	Transition of NBC CREST Human Response and Casualty Estimation Technology to JPM-IS

10:15AM – 11:00AM BREAK in Exhibit Area

Hazard and Environmental Modeling – Trinity Room A & B
Session Chair: Mr. Rick Fry, JSTO

Time	Author	Title
11:00AM –11:30AM	Dr. Todd H. Pierce, SAIC	DTRA Industrial Facilities Source Model
11:30AM – Noon	Dr. Steven R. Hanna, Hanna Consultants	Estimating Emissions of Toxic Industrial Chemicals (TICs) Released as a Result of Accidents or Sabotage

Data Assimilation and Tactical Applications – Pecos Room
Session Chair: Dr. John Hannan, JSTO

Time	Author	Title
11:00AM–11:30AM	Ms. Priya Sreedharan, LBNL	Robust Sensor Networks using Imperfect Sensor Data for Real-Time Detection of Toxic Releases
11:30AM – Noon	Mr. George Bieberbach, NCAR	Application of Advanced Numerical Weather Prediction Techniques for Improving CBR Source Characterization, within a Flexible Simulation and Evaluation Development Environment

Battle Management – Sabine Room
Session Chair: Mr. William Ginley, ECBC

Time	Author	Title
11:00AM – 11:30AM	Dr. Jiacun Wang, Monmouth University	Incident Command Systems Resource-Constrained Workflow Modeling and its Application to Military Command and Control Decisions
11:30AM – Noon	Mr. Thomas Aylesworth, Ricciardi Technologies, Inc.	JWARN Component Interface Device (JCID) Software-Based Sensor System

Data and Decision Support Tools – San Marcos Room
Session Chairs: Mr. Eric Lowenstein & Ms. Jessica Miller, JSTO

Time	Author	Title
11:00AM – 11:30AM	Mr. Gaylen W. Drape, ENSCO, Inc.	A Web-Based Knowledge Exploitation Toolset for the CBDP
11:30AM – Noon	Mr. Mallikarjun Shankar, Ph.D. Oak Ridge National Laboratory	Harmonizing CBIS Systems and Schemas for Seamless Operational Support

Medical Modeling – San Antonio Room
Session Chair: Ms. Angel Fitzgerald, JSTO

Time	Author	Title
11:00AM – 11:30AM	Dr. William J. Welsh, University of Medicine & Dentistry of New Jersey Robert Wood Johnson Medical School	Shape Signatures: Next-generation Drug Discovery Tool
11:30 AM – Noon	Dr. Gene E. McClellan, Applied Research Associates, Inc.	Medical Modeling of Particle Size Effects for Inhalation Hazards

Noon–1:00PM Lunch (On Your Own)

Hazard and Environmental Modeling – Trinity Room A & B
Session Chairs: Mr. Rick Fry & CDR Stephanie Hamilton, JSTO

Time	Author	Title
1:00PM – 1:30PM	Dr. Bernd Leitl, University of Hamburg	Wind Tunnel Modeling In Support of The Validation of Les-based Flow and Dispersion Simulations
1:30PM – 2:00PM	Dr. MiYoung Lee	Detailed 3D CFD Model of The University Hamburg Wind Tunnel for Inlet Boundary Conditions
2:00PM – 2:30PM	Mr. Michael J. Brown, LANL	Computationally Fast 3D Wind and Pressure Solvers for Buildings in Cities

Major Defense Acquisition Programs – Pecos Room
Session Chair: Mr. William Zimmerman, NSWC Dahlgren

Time	Author	Title
1:00PM – 1:30PM	TBD	MDAP
1:30PM – 2:00PM	Dr. Oliver Lanning, Defence Science and Technology Laboratory	Use of a Synthetic Environment to Support Acquisition
2:00PM – 2:30PM	Mr. Chris J. Gaughan, Edgewood Chemical Biological Center	Chem-Bio System Military Worth Assessment Toolkit

Battle Management – Sabine Room
Session Chair: Mr. William Ginley, ECBC

Time	Author	Title
1:00PM – 1:30PM	Dr. Richard N. Czerwinski, MIT Lincoln Laboratory	Sensor Alert Verification for Incident Operational Response (SAVIOR)
1:30PM – 2:00PM	Dr. Jack E. Fulton Jr. , NSWC Crane Division	Aspects of Detection and Identification of Chem-Bio Hazards in a Sensor Network Environment
2:00PM – 2:30PM	Dr. Jay S. Huebner, University of North Florida	Rapid Response Sensor Networking for Multiple Applications

Decision Support Tools – San Marcos Room
Session Chair: Ms. Jessica Miller, JSTO

Time	Author	Title
1:00PM – 1:30PM	Dr. LorRaine Duffy, JPM IS	Next Generation Tactical Situation Assessment Technology (TSAT)
1:30PM – 2:00PM	Christopher J. Gaughan, Edgewood Chemical Biological Center	Application of Swarm Network Models to the Efficient and Secure Distribution of Chemical and Biological Sensor Data
2:00 PM – 2:30 PM	Dr. Jerome J. Braun, MIT Lincoln Laboratory	Multi-Purpose Machine-Intelligence-based Information Fusion (FLASH)

Medical Systems – San Antonio Room
Session Chair: Dr. Rashid Chotani, JSTO

Time	Author	Title
1:00PM – 1:30PM	Dr. Jaideep Ray, Sandia National Laboratories	A Bayesian Approach for Estimating Outbreak Characteristics from Patient Data
1:30PM – 2:00PM	Dr. Ashok Gadgil, LBNL	Collective Protection from Outdoor Toxic Plumes by Sheltering-in-place Indoors: What Factors Matter Most in Effective Protection
2:00PM – 2:30PM	Dr. Rashid Chotani, JSTO	Infectious Disease Analysis Capability (IDAC)

2:30 PM – 3:30 PM BREAK–Last Opportunity to view Exhibits and Posters

Hazard and Environmental Modeling – Trinity Room A & B
Session Chairs: Mr. Rick Fry & CDR Stephanie Hamilton, JSTO

Time	Author	Title
3:30PM – 4:00PM	Dr. Thomas B. Harris, SAIC	MicroSWIFT/SPRAY: A Tool for Modeling Wind Fields and the Dispersion of WMD Agents over Complex Terrain and in Urban Environments
4:00PM – 4:30PM	Dr. Donald A. Burrows, ITT	A Fast-Running, High Quality, Transport and Dispersion System for Urban Areas
4:30PM – 5:00PM	Dr. John Hannan, JSTO	An Inter-comparison of Diagnostic Urban Wind Flow Models based on the Röckle Methodology using the Joint Urban 2003 Field Data
5:00PM – 5:30PM	Mr. Ian Griffiths, DSTL	Urban Dispersion and Data Handling in JEM

Major Defense Acquisition Programs – Pecos Room
Session Chair: Mr. William Zimmerman, NSWC Dahlgren

Time	Author	Title
3:30PM – 4:00PM	Mr. Russell Williams, JPM NBC Contamination Avoidance	Unit Mission Model for Chemical and Biological Defense Materiel Testing
4:00PM – 4:30PM	Mr. Michael Parham, US Army Edgewood Chemical Biological Center	The Air Purification Evaluation Tool (Apet), a Decision Support Tool for Air Purification Technology Trade Studies.
4:30PM – 5:00PM	Mr. Chris J. Gaughan, Edgewood Chemical Biological Center	Chem-Bio Simulation Suite Maturation/Transition
5:00PM – 5:30PM	Mr. Steven S. Streetman, ENSCO, Inc.	A Comprehensive Methodology for Evaluating the Effectiveness of CBRN Protection Systems

Battle Management – Sabine Room
Session Chair: Mr. William Ginley, ECBC

Time	Author	Title
3:30PM – 4:00PM	Mr. John T. Gray, Naval Surface Warfare Center, Dahlgren Division	Inter-LAN Socket Connection Manager (ILSCM)
4:00PM – 4:30PM	Dr. Dave Swanson, ARL Penn State University	JCID Compliant Thin Server for Sensors
4:30PM – 5:00PM	Mr. Chris Wasser, Northrop Grumman	Using a Programmable Software Defined Radio for Sensor Management
5:00PM – 5:30PM	Mr. Eric C. Hoenes, BAE Systems	Small, Low Power, Wmd Sensor Network With Satcom Reach Back Capability

Data and Decision Support Tools – San Marcos Room
Session Chairs: Ms. Jessica Miller & Mr. Eric Lowenstein, JSTO

Time	Author	Title
3:30PM – 4:00PM	Dr. Gerald R. Larocque, MIT Lincoln Laboratory	Decision Support using Mission Simulation and Modeling Tools
4:00PM – 4:30PM	Mr. Roshan Rammohan, University of New Mexico	Classical versus Evolutionary Multi-Objective Optimization Methods for Optimal Funding Allocations to Mitigate Chemical and Biological Attacks
4:30PM – 5:00PM	Mr. Jeffrey S. Steinman, Ph.D, WarpIV Technologies, Inc.	A Proposed Open Standard Architecture for Modeling and Simulation (OSAMS)
5:00PM – 5:30PM	Mr. James L. Ramsey, Sandia National Laboratories	BROOM: An Integrated Data Management and Analysis System for Chemical and Biological Restoration

Medical Systems – San Antonio Room
Session Chair: Dr. Rashid Chotani, JSTO

Time	Author	Title
3:30PM – 4:00PM	Mr. Farrukh (Ferg) Husain, Black & Veatch International	Electronic Integrated Disease Surveillance System (EIDSS)
4:00PM – 5:00PM	Dr. Carl Curling, IDA	Attributes of Human Response Modeling

6:30PM – 8:00PM CBIS Annual Banquet–Guest Speaker: TBD — Exhibitors are encouraged to attend.

Thursday, January 11, 2007

8:00AM – 8:30AM Continental Breakfast and Registration

8:30AM – 8:45AM Administrative Remarks

Hazard and Environmental Modeling – Trinity Room A & B
Session Chairs: Mr. Rick Fry & CDR Stephanie Hamilton, JSTO

Time	Author	Title
8:45AM – 9:15AM	Dr. Steven R. Hanna, Hanna Consultants	Comparison of Observed, MM5 and WRF Model-Simulated and HPAC-Assumed Boundary Layer Meteorological Variables for Five Days during the IHOP Field Experiment
9:15AM – 9:45AM	Dr. Nathan Platt, IDA	Evaluations of URBAN HPAC Configurations with Joint Urban 2003 Field Trials
9:45AM – 10:15AM	Dr. James Heagy, IDA	Joint Effects Model Urban IPT

Data Assimilation and Tactical Applications – Pecos Room
Session Chair: Dr. John Hannan, JSTO

Time	Author	Title
8:45AM – 9:15AM	Dr. Martyn D. Bull, RiskAWare	Sensor Placement Algorithm for Rapid Theatre Assessment (SPARTA)
9:15AM – 9:45AM	Dr. Michael D. Sohn, LBNL	Optimal Networks for Probabilistic Siting of Bio-Samplers in Buildings
9:45AM – 10:15AM	Mr. Michael J. Smith, ITT	SLOTS: The Development of a Genetic Algorithm – based Sensor Location Optimization Tool

Battle Management – Sabine Room
Session Chair: Mr. William Ginley, ECBC

Time	Author	Title
8:45AM – 9:15AM	Mr. Donald W. Macfarlane, US Army Edgewood Chemical Biological Center	Understanding the Operational Environment is Key to Fielding Valuable Systems–Lessons Learned from CASPOD
9:15AM – 9:45AM	Mr. Javad Sedehi, ITT Corp	No Body Cares – A Case for Integrated Base Force Protection
9:45AM – 10:15AM	Mr. Keith Kunz, BAE Systems	Unattended Early Warning, Intelligence Data Collection and Bomb Damage Assessment Related To Chemical Warfare Agent And Toxic Industrial Chemicals

Data and Decision Support Tools – San Marcos Room
Session Chair: Ms. Jessica Miller, JSTO

Time	Author	Title
8:45AM – 9:15AM	Mr. Frank Gilfeather, Ph. D University of New Mexico	Chem-Bio – Multivariate Investment Decision Support Tool–MIDST
9:15AM – 9:45AM	Dr. William Ogden, Computing Research Laboratory New Mexico State Univ.	Understanding DTRA S&T Investment strategies
9:45AM – 10:15AM	Ms. Shan Xia, University of New Mexico	“A Modular Architecture for Multivariate Investment Decision Support”

Threat Agent Science – San Antonio Room
Session Chair: Dr. Alison Director-Myska, JSTO

Time	Author	Title
8:45AM – 9:15AM	Dr. Douglas Burns, ENSCO, Inc.	Computational Chemistry: Example Applications of a Critically Important Tool in Threat Agent Science
9:15AM – 9:45AM	Dr. George R. Famini, DHS Chemical Security Analysis Center	An Introduction to the DHS Chemical Security Analysis Center
9:45AM – 10:15AM	Mr. Joseph Chipuk, Signature Science, LLC	Computational Chemistry Techniques Applied to Chemical Warfare Agents (CWA) to support Chemical Analysis, Detection and Threat Assessment Programs

10:15AM – 11:00AM BREAK

Hazard and Environmental Modeling – Trinity Room A & B
Session Chair: CDR Stephanie Hamilton, JSTO

Time	Author	Title
11:00AM –11:30AM	Dr. Steven R. Hanna, Hanna Consultants	JEM IV&V – Evaluations of JEM with Field Observations
11:30AM – Noon	Mr. Jeffery T. McQueen, NOAA/NWS/NCEP/EMC	An Overview of The Noaa National Centers for Environmental Prediction (NCEP) Meteorological Model Products and Their Application for Atmospheric Transport and Dispersion Studies

Data Assimilation and Tactical Applications – Pecos Room
Session Chair: Dr. John Hannan, JSTO

Time	Author	Title
11:00AM – 11:30AM	Mr. Oliver Lanning, DSTL	Fusion of Sensor and Model Data
11:30AM – Noon	Dr. Tarunraj Singh, University of Buffalo	Data Assimilation for Puff Model-based Chem-Bio Dispersion

Battle Management – Sabine Room
Session Chair: Mr. William Ginley, ECBC

Time	Author	Title
11:00AM – 11:30AM	Ms. Kassandra Shigley, Northrop Grumman	Information Assurance Implications for Unattended Sensors
11:30AM – Noon	Mr. Paul Thomas, DSTL	NATO CBRN CIS

Data and Decision Support Tools – San Marcos Room
Session Chair: Ms. Jessica Miller, JSTO

Time	Author	Title
11:00AM – 11:30AM	Dr. Heidi Ammerlahn, Sandia National Laboratories	Decision Aids for CBRN Investment Planning & Analysis
11:30AM – Noon	Mr. Michael O. Kierzewski, US Army RDECOM, ECBC	Chem-Bio Virtual Prototyping Benefit and Feasibility

Threat Agent Science – San Antonio Room
Session Chair: Dr. Alison Director-Myska, JSTO

Time	Author	Title
11:00AM –11:30AM	Mr. Michael Henley, Air Force Research Lab/ MLQL	Atmospheric Chemistry of Toxic Industrial Chemicals
11:30 AM – Noon	Dr. Douglas Burns, ENSCO, Inc.	Improvement and Sensitivity Analysis of the Atmospheric Chemistry Module for Modeling TICs in SCIPUFF

Noon–1:00PM LUNCH (On your own)

Hazard and Environmental Modeling – Trinity Room A & B
Session Chairs: Mr. Rick Fry & CDR Stephanie Hamilton, JSTO

Time	Author	Title
1:00PM – 1:30PM	Maj Tony Eckel, AFWA	Supporting Transport and Dispersion Modeling with Stochastic Weather
1:30PM – 2:00PM	Mr. George Bieberbach, NCAR	Joint Effects Model (JEM) Environmental Services Research and Development
2:00PM – 2:30PM	Dr. Dennis M. Garvey, ARL	Turbulence in the Stable Boundary Layer

Operational Effects – Sabine Room
Session Chair: Mr. Mark Fagan, AFRL

Time	Author	Title
1:00PM – 1:30PM	Mr. Christopher M. Clem, DSTL	Development of CBRN Impact Assessment Capabilities
1:30PM – 2:00PM	Mr. Andrew Howe, DSTL	IMPACT Framework
2:00PM – 2:30PM	Mr. Ian Griffiths, DSTL	Using Experimentation to Support Future Capability Needs: Chem-Bio effects in the JFCOM Urban Resolve Experiment

Testing & Evaluation – San Marcos Room
Session Chair: Ms. Laura Sears, JSTO

Time	Author	Title
1:00PM – 1:30PM	Mr. Jeffery D. Peterson, Dugway Proving Ground	Overarching Collective Protection Model for Test and Evaluation
1:30PM – 2:00PM	Dr. Leonard N. Carter, U.S. Army Dugway Proving Ground	A New M&S Tool to Supplant Decontamination Testing: The Decontamination Efficacy Prediction Model
2:00PM – 2:30PM	Mr. James A. Kleimeyer, Ph.D., West Desert Test Center	Overarching Contamination Avoidance Model for Test and Evaluation

Threat Agent Science – San Antonio Room
Session Chair: Dr. Alison Director-Myska, JSTO

Time	Author	Title
1:00PM – 1:30PM	Mr. Bojan Markicevic, Kettering University	Experimental and Numerical Prediction of Phase Permeability in Porous Media
1:30PM – 2:00PM	Mr. Homayun K. Navaz, Kettering University	Scalable Transport Models for Non-Evaporating and Evaporating Sessile Droplets within Porous Substrates
2:00PM – 2:30PM	Mr. Kilpatrick	Agent Fate Predictive Modeling

2:30PM – 3:00PM BREAK

Hazard and Environmental Modeling – Trinity Room A & B
Session Chair: CDR Stephanie Hamilton, JSTO

Time	Author	Title
3:00PM – 3:30PM	Dr. David Stauffer, PSU	On the Role of Atmospheric Data Assimilation and Model Resolution on Meteorological Accuracy and Atmospheric Transport and Dispersion
3:30PM – 4:00PM	Dr. Leonard J. Peltier, ARL/PSU	Assessing the Impact of Meteorological Model Uncertainty on SCIPUFF Atmospheric Transport and Dispersion Predictions
4:00PM – 4:30PM	Mr. Walter Kolczynski Jr., PSU	A Practical Method for Calibration of Ensemble Spread for Representation of Meteorological Uncertainty in Atmospheric Transport and Dispersion Models
4:30PM – 5:00PM	Dr. William J. Coirier, CFDRC	Progress Towards An Improved High-Fidelity Forecasting Capability using Combined Mesoscale and Microscale Models
5:00PM – 5:30PM	Mr. Matthew C. Ward, Applied Science Associates	Development of an HPAC/JEM Waterborne Chemical and Biological Agent Transport Modeling Capability

Operational Effects – Sabine Room
Session Chair: Mr. Mark Fagan, AFRL

Time	Author	Title
3:00PM – 3:30PM	Mr. Kip Reeths, Cubic	JOEF Transitions Legacy Applications to a Service-Oriented Architecture
3:30PM – 4:00PM	Dr. Nadipuram (Ram) R. Prasad, New Mexico State University	Mining for resource effectiveness to mitigate Chem-Bio attack consequence
4:00PM – 4:30PM	Mr. Darius Munshi, Cubic Defense Applications	CBRN Data Import Export Tool
4:30PM – 5:00PM	Dr. Stephen Helmreich, Computing Research Laboratory New Mexico State Univ.	Chem-Bio engagement scenario space, Chem-Bio engagement scenarios, and the CBRN Data Model
5:00PM – 5:30PM	Mr. Dave Hoffman, UNM	Mobile Forces

Testing & Evaluation – San Marcos Room
Session Chair: Ms. Laura Sears, JSTO

Time	Author	Title
3:00PM – 3:30PM	Dr. Martyn Bull, RiskAware, Ltd	Concentration Fluctuation Model for the Virtual Testing of CBRN Detector Systems
3:30PM – 4:00PM	Dr. Ashok J. Gadgil, Lawrence Berkeley National Laboratory	Decontamination of ductwork using Vaporous Hydrogen Peroxide: Comparison between experiments and CFD predictions
4:00PM – 4:30PM	Dr. Elena Abadjieva and Dr. Renier Sterkenburg, HAPPIE/RIOT	HAPPIE/RIOT A Dutch Missile Intercept Simulator
4:30PM – 5:00PM	Ms. Jennifer Park,	Standardizing VV&A Documentation

Threat Agent Science – San Antonio Room

Session Chair: Dr. Alison Director-Myska, JSTO

Time	Author	Title
3:00PM – 3:30PM	Dr. Tom J. Evans, Cubic Threat Technologies Division	Quantum Chemical Theory Research
3:30PM – 4:00PM	Dr. William A Brence, Battelle	Development of in-silico Predictive Molecular Modeling Tools to Identify, Validate and Select Operationally Suitable Agent Simulants for OT&E
4:00PM – 4:30PM	Dr. William J. Welsh, University of Medicine & Dentistry of New Jersey Robert Wood Johnson Medical School	Next-Generation Computational Chemistry Tools to Predict Toxicity of CWAs

5:30PM Conference Adjourns

POSTERS ARE LOCATED IN THE EXHIBIT HALL
(During Exhibit Hours Only)

Author	Title
Dr. William J. Coirier, CFDRC	Calibration and Use of Site-Specific Urban Weather Observations Data using Microscale Modeling
Mr. Robert M. Kelly Jr., Monmouth University	Innovative Emergency Response Information Technology Applications: Civilian to Military Crossover Opportunities
Mr. Jack Berndt, OptiMetrics Inc	Using ADASHI to bring Civil and Military First Responders together
Dr. Robert Gordon, RiskAware, Ltd.	Effective Presentation of CBRN Hazards
Dr. Cory Davis, MadahCom	Warning, the Critical Element
Mr. Joshua Pressnell, JPEO-CBD Software Support Activity	The Road to Net Centricity : A Common Direction
Mr. David A. Ence, Lockheed Martin	DEFENDER – An Enterprise Architecture and Integrated Network Solution for CBRN Detection
Mr. Steven S. Streetman, ENSCO, Inc.	Integrating Sensors and Operator/Responder Actions to Improve CBRN Incident Management
Mr. Hung Dang, NMSU	On Sensitivity and Credit Analysis for Decision Support Systems

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY
2111 Wilson Boulevard
Suite 400
Arlington, VA 22201

2007 Chemical Biological Information Systems Conference & Exhibition
January 8 - 11, 2007
Renaissance Austin Hotel, Austin, TX

Sensor Alert Verification for Incident Operational Response (SAVIOR)

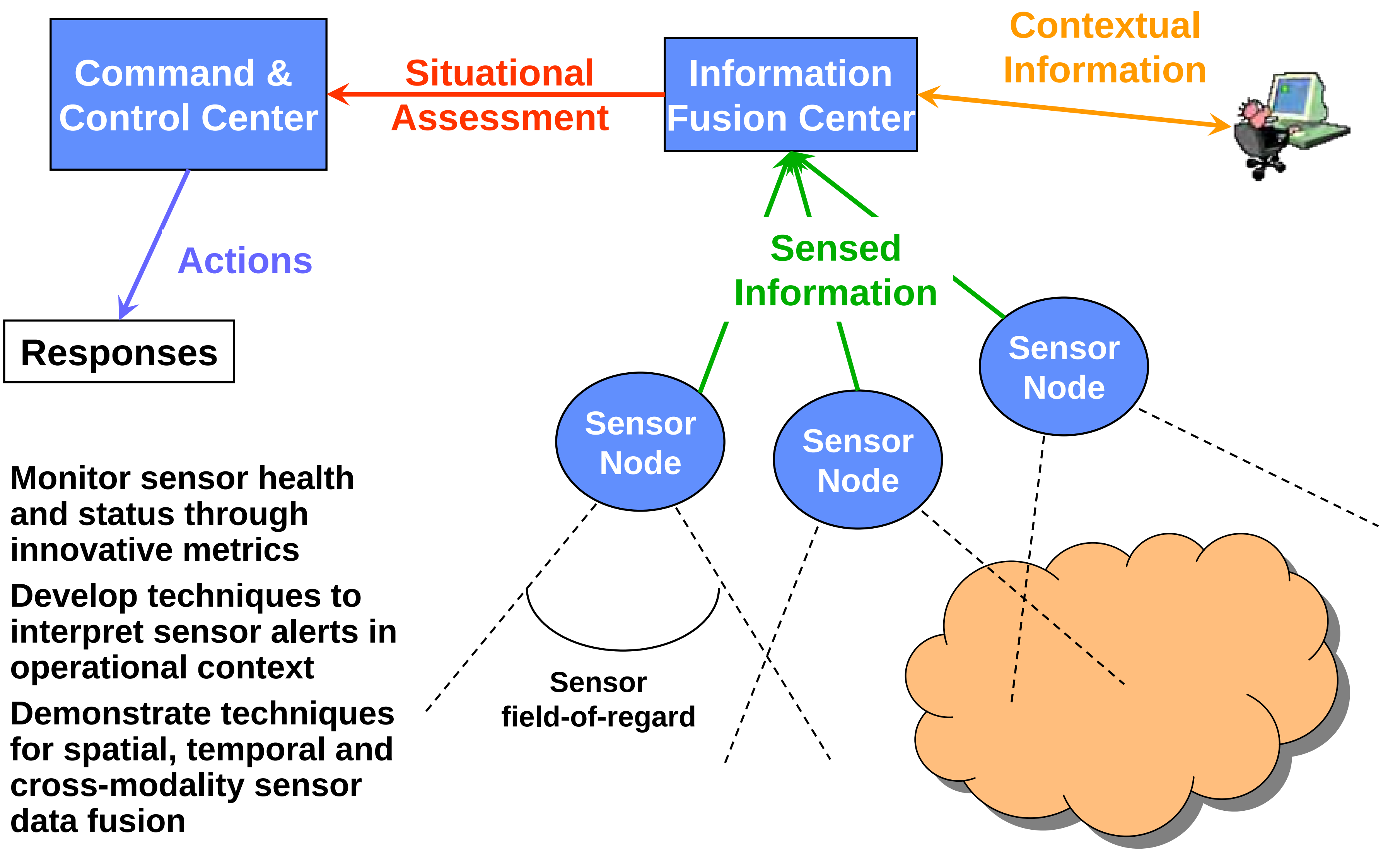
Richard Czerwinski

Sensor Technology and System Applications Group

Chemical and Biological Information Systems
Austin, TX
10 January 2007

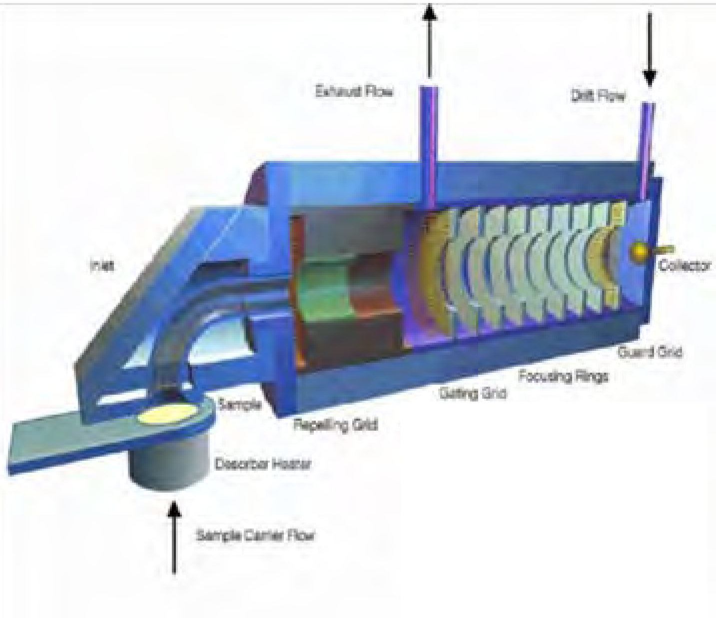
This work was sponsored by DTRA under Air Force Contract FA8721-05-C-0002. Opinions, interpretations, conclusions, and recommendations are those of the author and are not necessarily endorsed by the United States government.

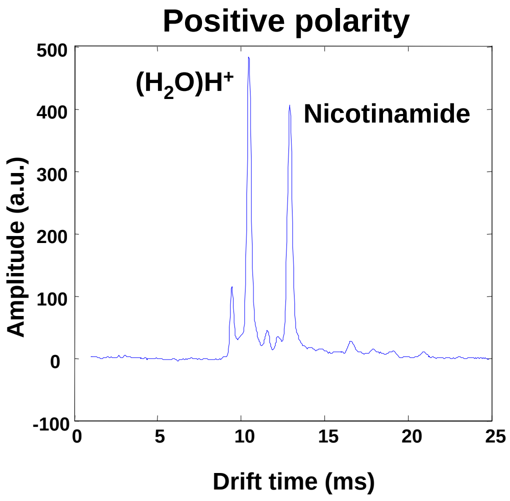
SAVIOR Concept

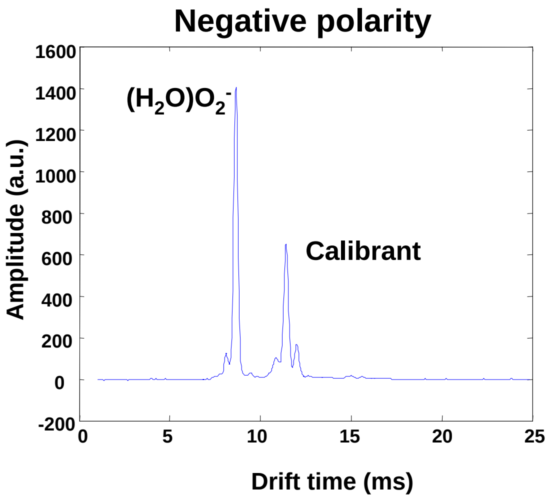


- Monitor sensor health and status through innovative metrics
- Develop techniques to interpret sensor alerts in operational context
- Demonstrate techniques for spatial, temporal and cross-modality sensor data fusion

Ion Mobility Spectrometry (IMS)







- **Sensor “plasmagram” features indicate presence of target chemicals**
  - **High sensitivity but affected by false alarms**

Alarm Category	Cause	Mitigation Strategy
Errant	Discrepancy between measured and expected drift times	Identify indicators of sensor health and status Improve instrument calibration to compensate
Ambiguous	Benign background chemicals with mobility similar to threat	Exploit data from orthogonal sensors Improve understanding of environment

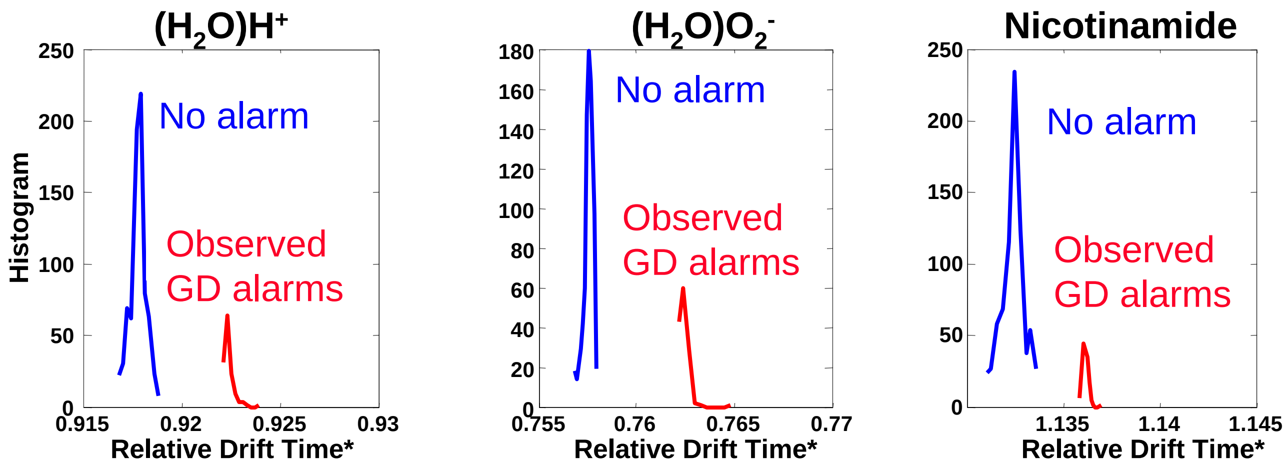
AREAS OF RESEARCH

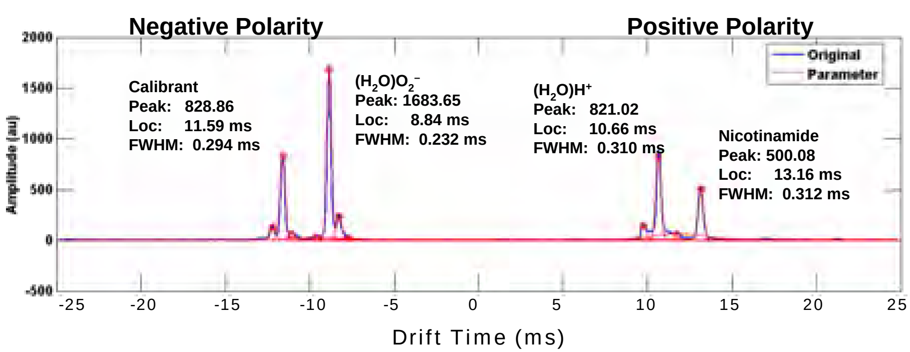
Outline

- Concept
- SAVIOR techniques
  - False alarm mitigation
  - Sensor fusion
  - Information fusion
- Ongoing and Planned Experiments
  - HaLT/HEPS
  - Sensor Health and Status
  - Operational Sensor Network
- Summary

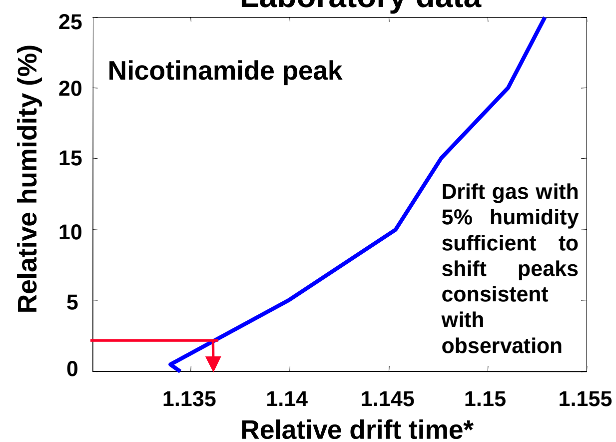
Analysis of Operational and Laboratory Data

Operational Data collected September-October 2003





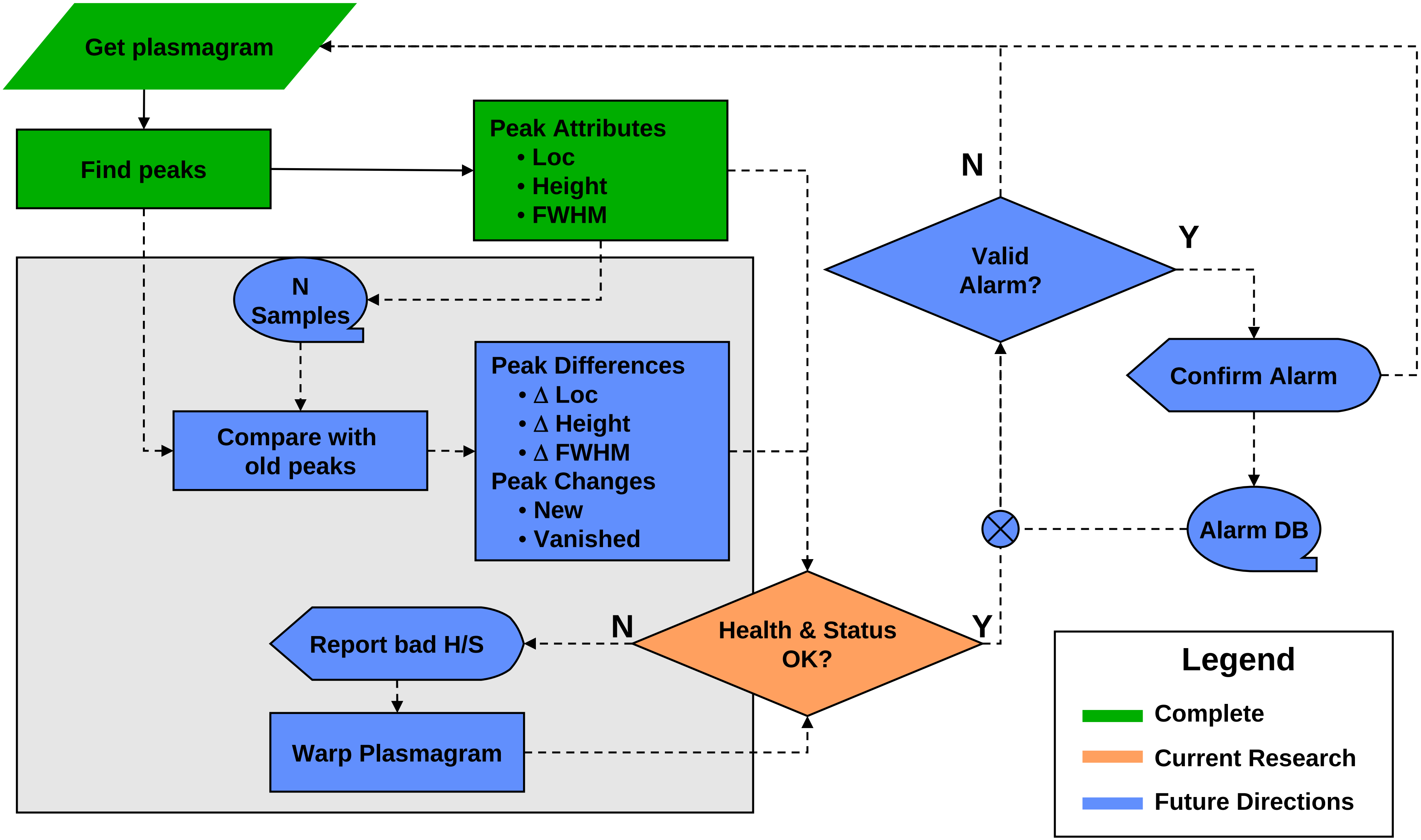
Laboratory data



Amplitudes and drift time ratios of standard peaks can indicate instrument health and status

*Relative to calibrant

IMS False Alarm Mitigation



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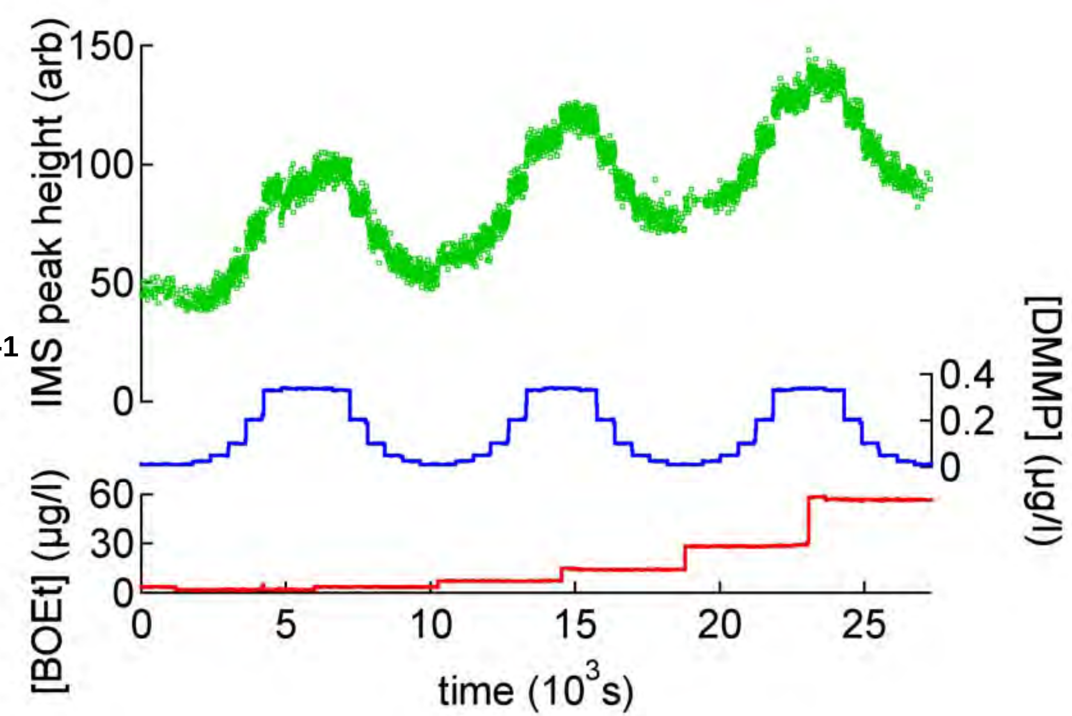
IMS Measurements: Simulant and Interferent

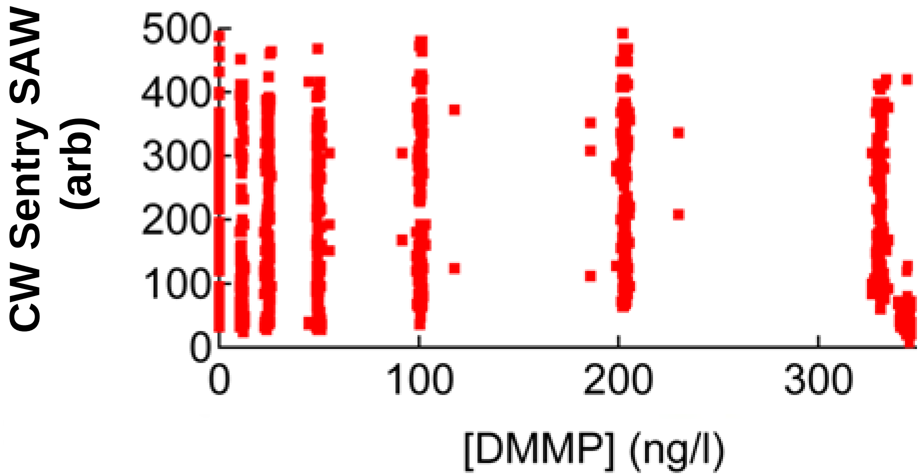
- **In the IMS, BOEt (2–Butoxyethanol) is an interferent for GB**
  - **GB: $k_0 = 1.250\ cm^2\ V^{-1}\ s^{-1}$**
  - **BOEt: $k_0 = 1.254\ cm^2\ V^{-1}\ s^{-1}$**
- **Many common products* containing BOEt could generate false alarms**
  - **Formula 409**
  - **Windex**
  - **RustOleum**
  - **> 200 other household cleaning products**

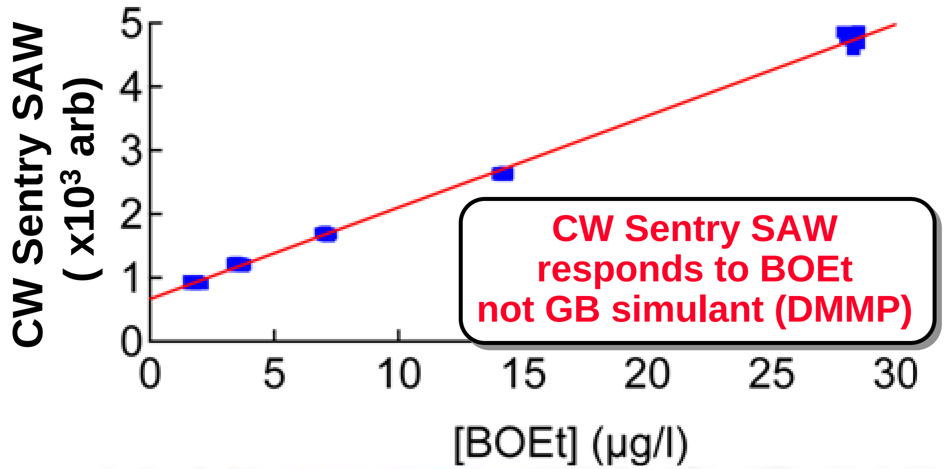


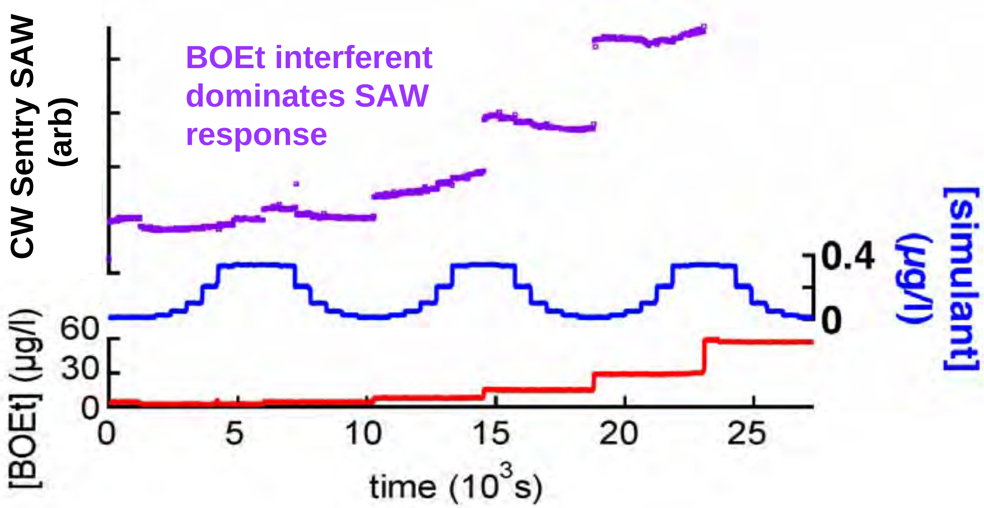
Simulant and interferent add constructively to IMS response

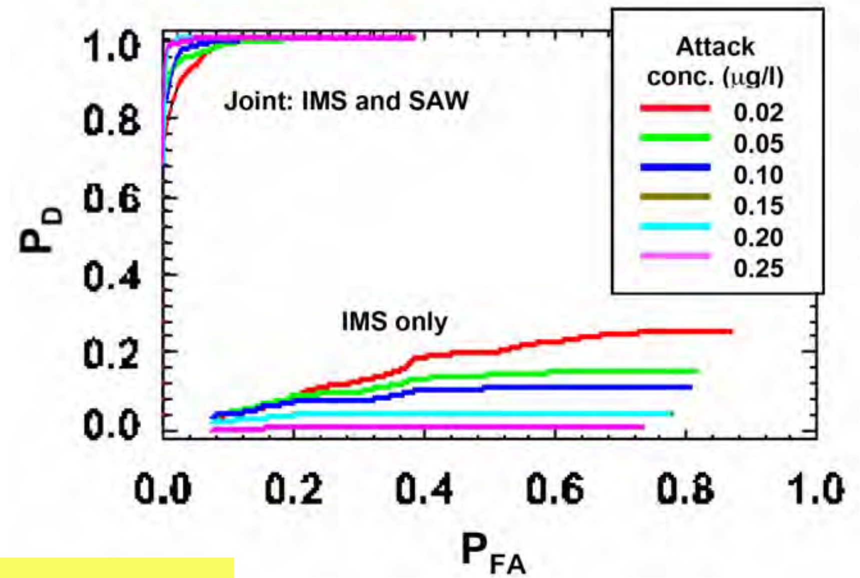
* http://householdproducts.nlm.nih.gov/cgi-bin/household/brands?tbl=chem&id=45

Orthogonal Sensors: IMS and SAW





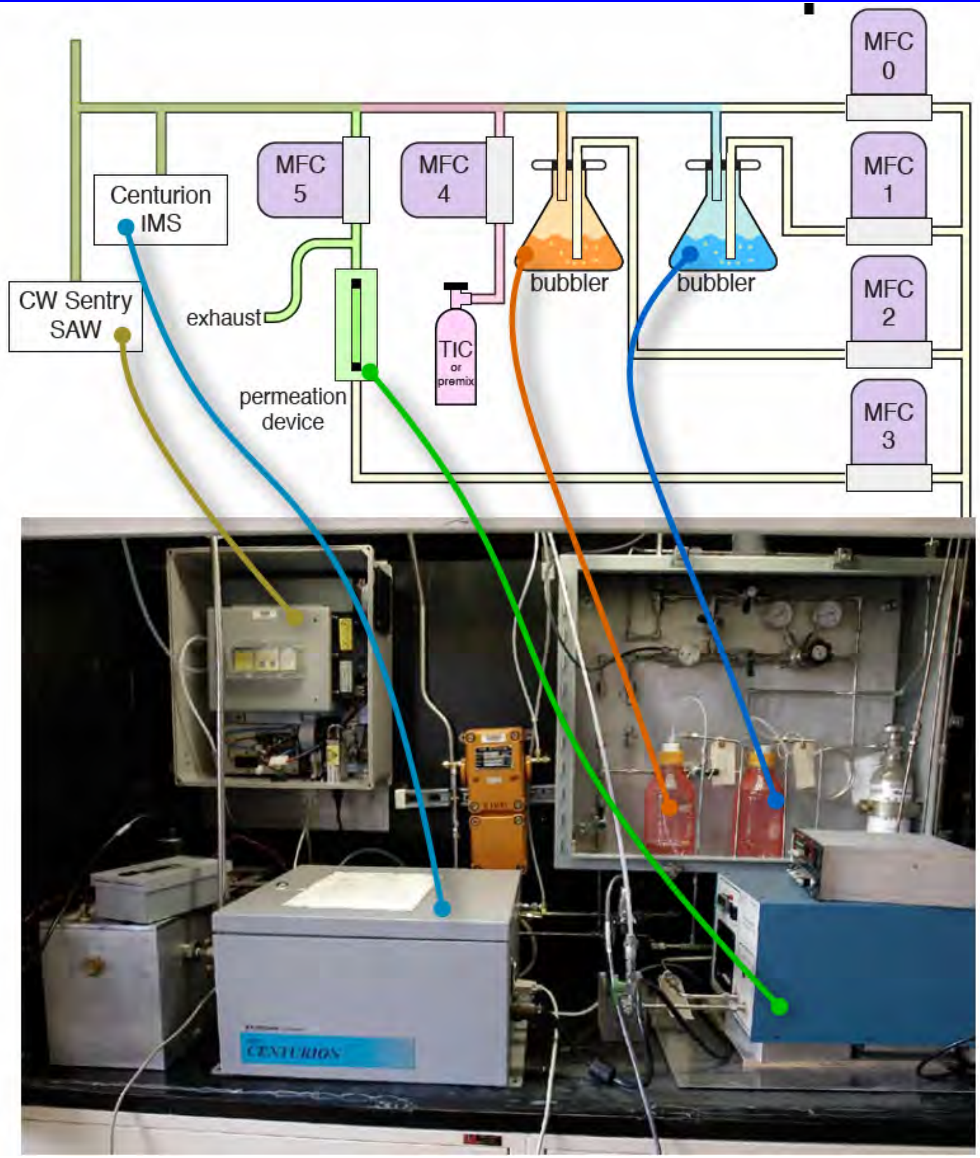




Joint detection capability much greater than IMS-only

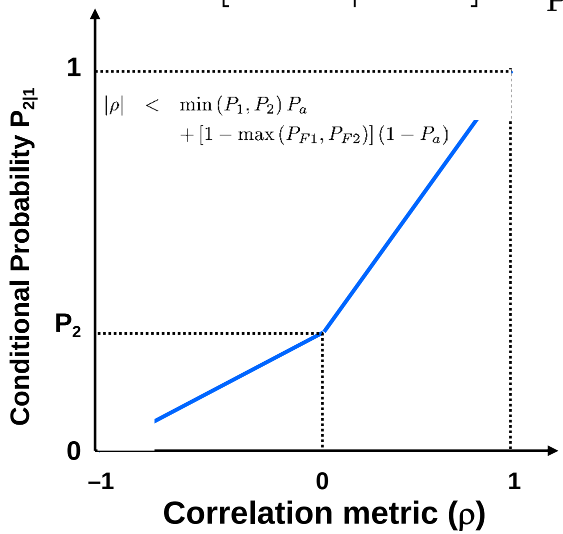
Chemical Vapor Testbed

- Simultaneous delivery of vapor to multiple sensors
- Computer controlled dilution of multiple components into clean, dry air stream
- No live agents
- Automated 24-hour operation
- Off-line Agilent GCMS for truth sensing



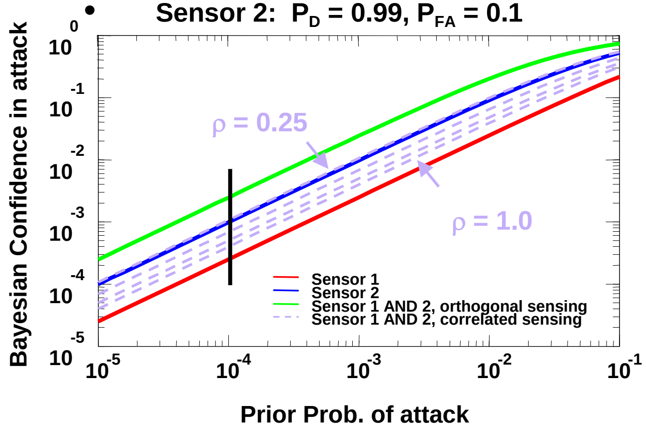
Correlation metric for sensors

$$\text{Prob[attack|alarm]} = \frac{\text{Prob[alarm|attack]Prob[attack]}}{\text{Prob[alarm|attack]Prob[attack]}+\text{Prob[alarm|no attack]}(1-\text{Prob[attack]})}$$

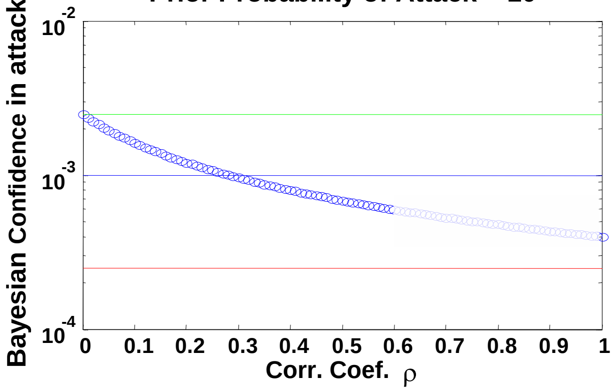


- **Prob[joint alarm | attack] = P_{12}**
- **$P_{12} = 0.5\,[\,P_1 P_{2|1} + P_2 P_{1|2}\,]$**
- **$P_{2|1} = P_2$ and $P_{1|2} = P_1$ only if sensors are uncorrelated**
- **Define correlation metric ρ**
  - **Note: Sensors with different P_D & P_{FA} <u>can not</u> have correlation ρ = 1**

- **Sensor 1: $P_D = 0.999$, $P_{FA} = 0.4$**
- **Sensor 2: $P_D = 0.99$, $P_{FA} = 0.1$**



- **Sensor 1: $P_D = 0.999$, $P_{FA} = 0.4$**
- **Sensor 2: $P_D = 0.99$, $P_{FA} = 0.1$**
- **Prior Probability of Attack = 10^{-4}**



Outline

- **Concept**
- **SAVIOR techniques**
  - **False alarm mitigation**
  - **Sensor fusion**
  - **Information fusion**
- **Ongoing and Planned Experiments**
  - **HaLT/HEPS**
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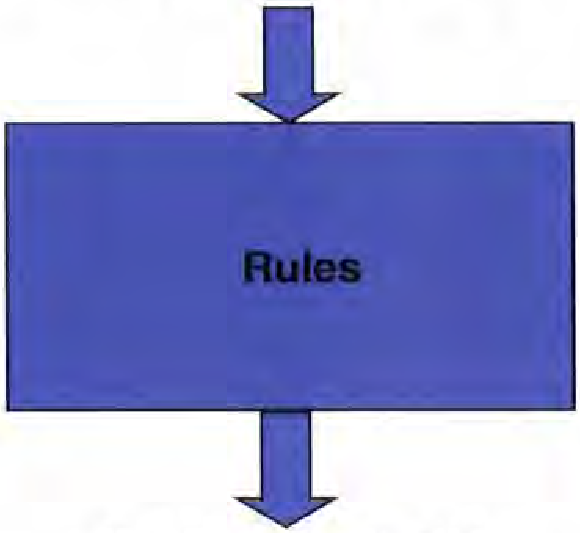
  - **Operational Sensor Network**
- **Summary**

Discrimination Architecture

- Sensor Measurements
- Ancillary Information
  - Situation awareness
  - Sensor health and status

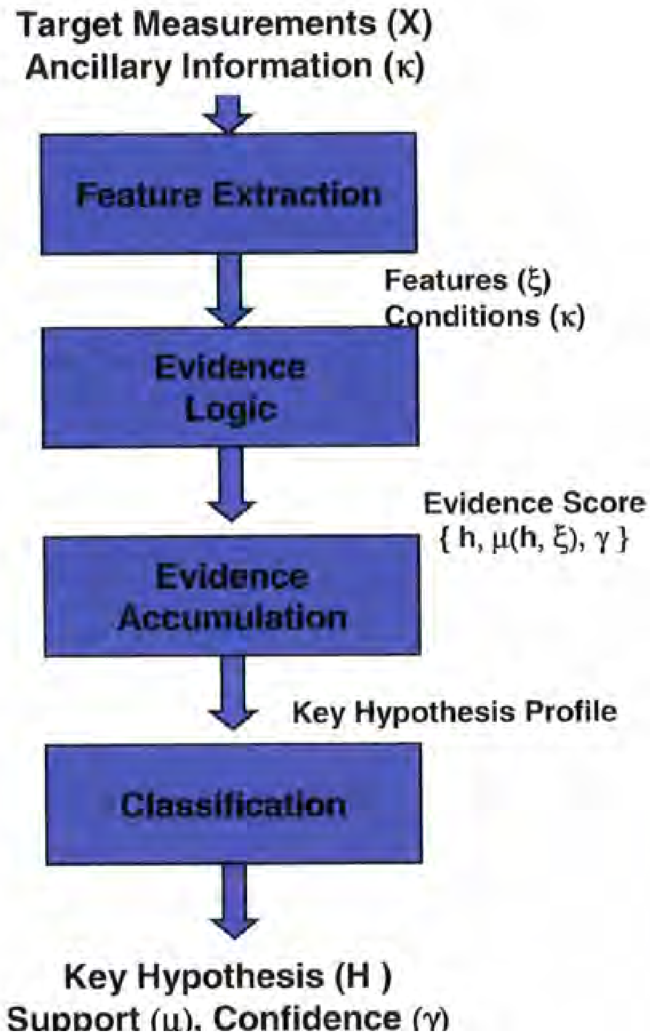


- Key Hypothesis (H)
- Support (μ)
- Confidence (γ)

Discrimination architectures are rules that map target measurements to a Key Hypothesis and two qualifiers: Support and Confidence.

- Key Hypothesis (H) is a conjecture about the composition of the target that caused the measurements
- Support (μ) is a measure of the suitability of the hypothesis given the evidence
- Confidence (γ) gauges the reliability of the measurements or a priori information on which the support is based

Discrimination Architecture Components



Extracts features from measurements

Measurements → Features

Interprets the features

Features → $\{ h, \mu(h, \xi), \gamma \}$

Accumulates all evidence and computes the support rendered to a set of pre specified Key Hypothesis

Evidence → Key Hypotheses Profile

Employs a decision rule to assign target to one of the Key Hypothesis (Target Class)

Key Hypotheses Profile → most likely Key Hypothesis

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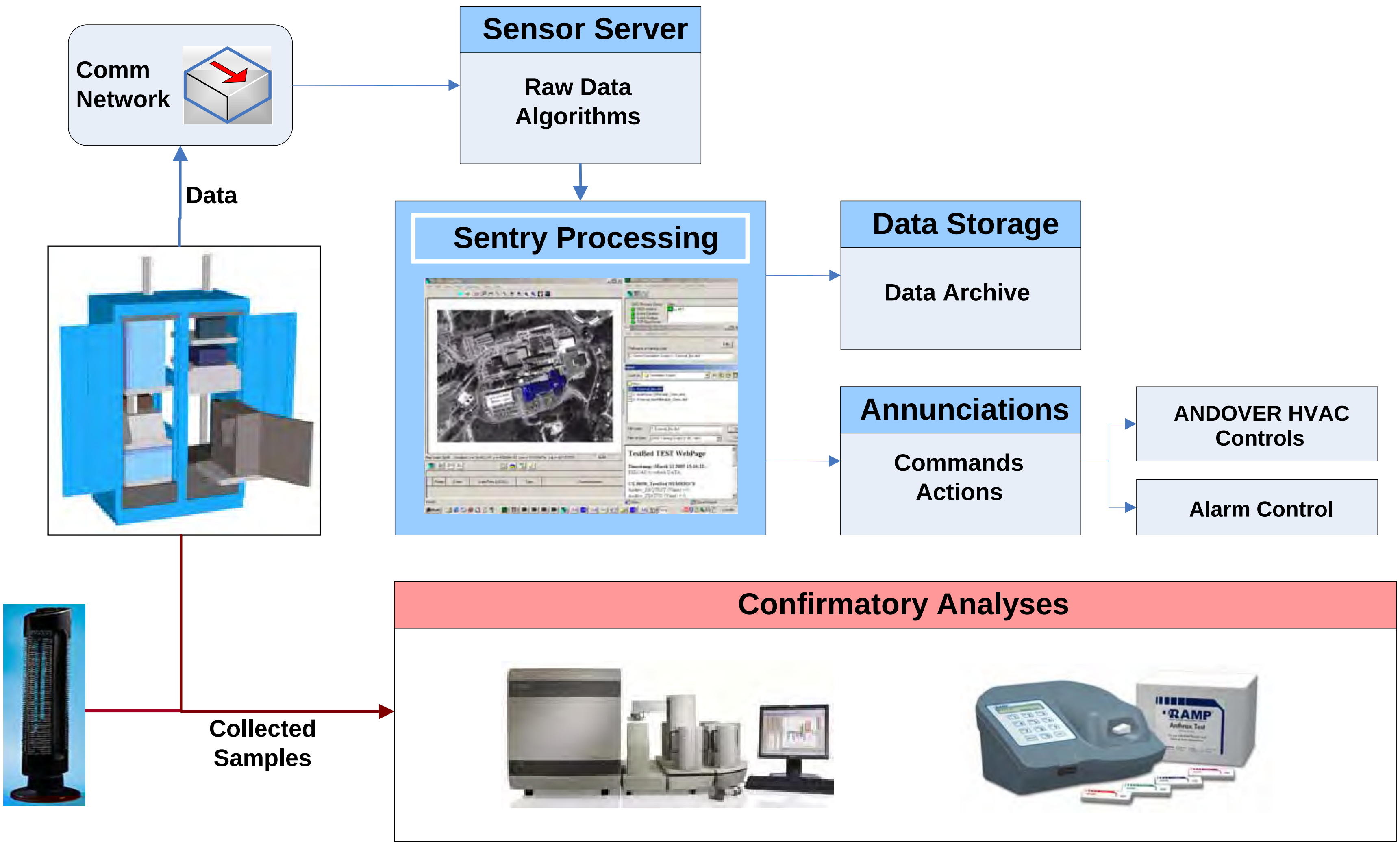
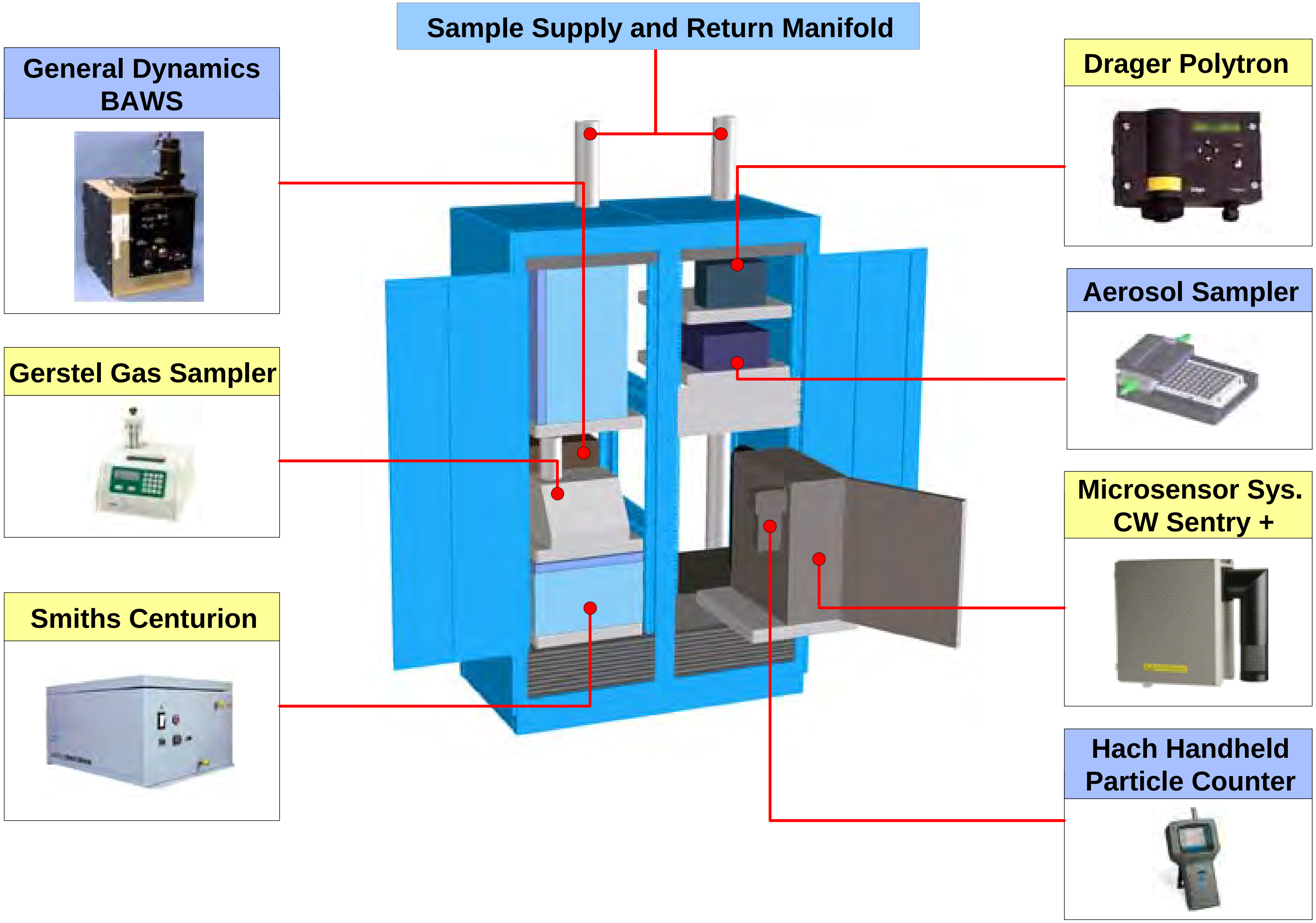
Key Components of the Phase 1 System
Communications & Control Interface



Key Components of the Phase 1 System

Point Sensor Node



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Sensor Health and Status

- **IMS requires stable atmospheric conditions in drift tube**
  - **Example: Smiths Centurion maintains temperature, humidity, pressure, etc. through a system of pumps, chemical desiccant material**
  - **Deviations from nominal atmosphere can shift peaks and alter instrument sensitivity**
- **Experiment:**
  - **Service sensor by replacing desiccant material with a mixture of new and spent desiccant**
  - **Monitor failure of desiccant over span of weeks, rather than months**
  - **Experiment initiated November 2006, results forthcoming**

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Scenario*

Example of Real World Data and the need for Fusion

- Data taken from live network in desert setting
  - 13 LCD3s running 24/7 for five months
  - Multiple instances of expected and unexpected detections
    - 998 Sulfur Dioxide (expected)
    - 972 Hydrogen Fluoride (unexpected)
    - 8 Cyanogen Chloride (unexpected)
    - 2 Sarin (unexpected)
    - 1 Phosgene (unexpected)
- Nuisance algorithm required to knock down HF alarms
- LCD3s don't provide a concentration level so another detector is required to confirm the level like the MultiRAE.

*Source: Bill Ginley, "Sensor Integration and Fusion," 16 May 2006

Operational Data Analysis

- **Anecdotal evidence from the field indicates HF alarms are due to instrument malfunction**
  - **Sensor operating outside nominal temperature range**
- **Experimental plan:**
  - **Data received from field November 2006; analysis underway to identify detectable data features indicating imminent sensor malfunction**
  - **LCD-3 sensor obtained for use in fume hood**
    - **Controlled exposure to heat, humidity and pressure excursions**
    - **Controlled exposure to real HF to compare with reference signature**

      HF exposure requires additional equipment, e.g. Teflon coated manifolds to prevent damage to experimental equipment and contamination of experiment with reaction products of HF with manifold lining

      Data collection anticipated approximately January 2007 when equipment will be available

Summary

- **Tasked with developing decision support techniques for chemical defense network application**

- **A sensor-based program with thrusts related to**
  – **Improving sensor performance**
    - **Signal processing**
    - **Background characterization**
  – **Fusing data from orthogonal co-located instruments**
  – **Fusing information from disparate information sources**

- **An experimental program which will provide instrumented truth for comparison with chemical sensor data**
  – **To provide context for operational measurements**
  – **To assist in understanding observable failure modes of sensors**
  – **Leveraging ongoing sensor deployment in office environment**

- **Leveraging MIT LL experience in**
  – **Ballistic missile defense**
  – **CW agent detection**
  – **Decision support techniques**

Use of a Synthetic Environment to Support Acquisition

Deb Fish, Alex Hill*, Neil Bowman,
David Brook and Chris Cooper

Defence Science and Technology Laboratory, UK
* Defence Science and Technology Organisation, AUS

Introduction

- There is a growing use of synthetic environments to augment laboratory and field experiments that support the acquisition of improved military capability
- The synthetic environments can be used in several ways
  - To make the initial business case for a new acquisition program or to identify new lines of development
  - To shape the research program
  - To test and evaluate equipment
- Dstl's Virtual Battlespace has been used to support the acquisition program in areas including
  - Biological area detection
  - Low-burden protective clothing

What is the Virtual Battlespace?

- A synthetic environment including (some under development)
  - State-of-the-art dispersion models (UDM & SCIPUFF)
  - Models of CBR defence system (detection, protection, MCMs)
  - Representation of movement of entities (aircraft, army units)
  - Links to combat & facility models (WISE, OneSAF, STAFFS)
  - Multiple run controller
  - Wargaming mode

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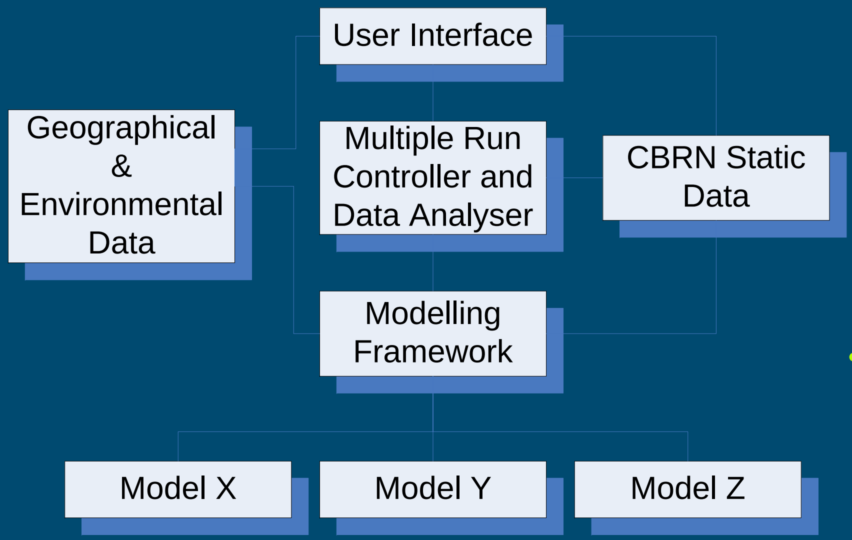
The Virtual Battlespace Models

- Dispersion Modelling
  - CBR sources and hazard plumes (weapons, IEDs, RDDs, TICs & TIMs)
  - Urban and Rural (SCIPuff & UDM)
  - Concentration Realisation
- Meteorology
  - Terrain
  - Local Wind Turbulence
  - Sea Breeze



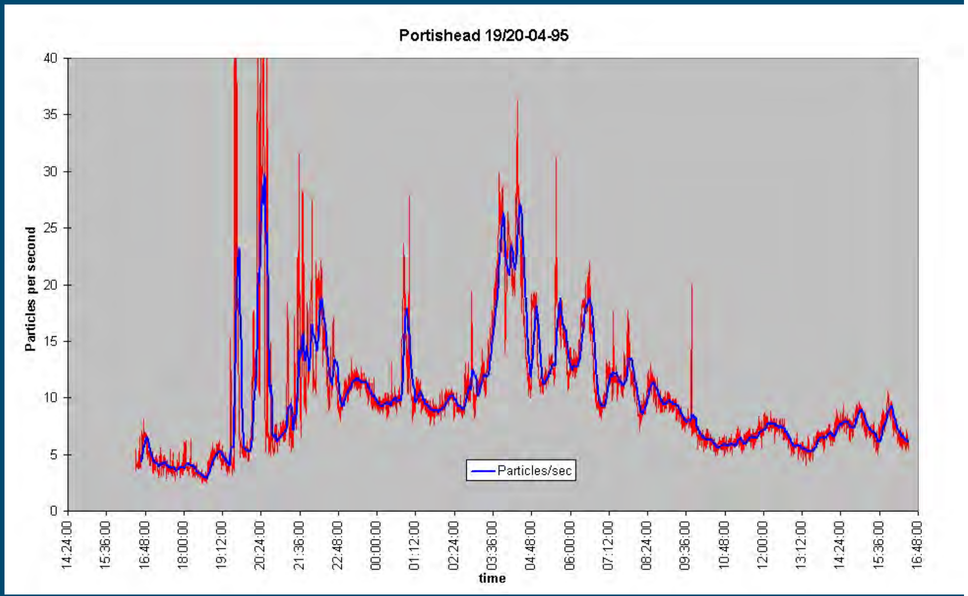
- Military Units/Personnel
  - Effects (casualties)
  - Inhalation & Contact Hazard (liquid pickup)
  - Medical Countermeasures
  - IPE
  - Physiological Burden
  - Aggregation
  - Value of Information
- Detectors
  - Simple (threshold)
  - Generic
  - Specific
  - Standoff
  - Biological Background
  - Single & Network Alarms
- Modes of Use
  - Wargaming
  - Assessment

Biological Area Detection

- Previous work on acquiring the Integrated Sensor Management System
- Now a soft OA workshop study will define the concepts of use for an area detection capability
- This will quantify capability provided by networks of generic, specific and stand-off detectors in the CBVB
- Two main aims of the work:
  - Guide the research programme by estimating the performance of current and planned detectors
  - Allow stakeholders to make informed decisions by demonstrating what is and isn't feasible

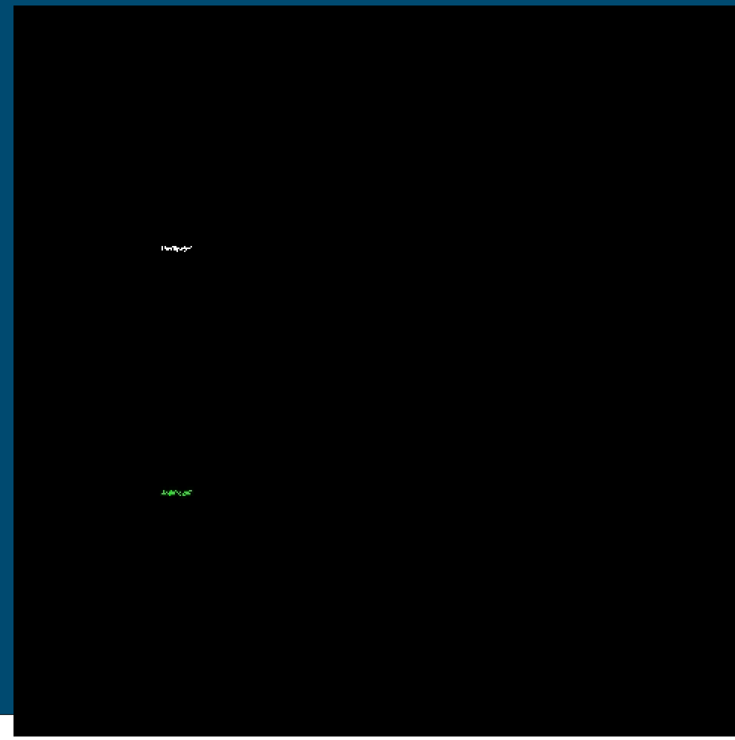
Integrated Sensor Management System (ISMS)

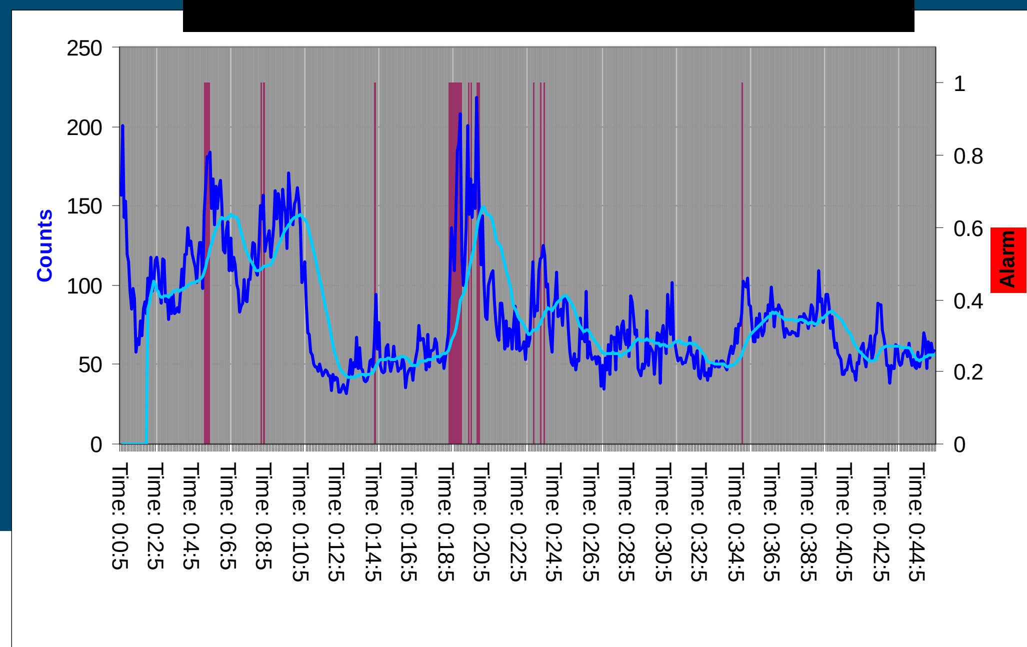
- Dstl supported the Defence Procurement Agency's assessment of systems developed by industry
  - Field trials expensive; detectors not available
- Therefore the assessment carried out in the Virtual Battlespace
  - Realistic simulation of biological background & turbulent, meandering plumes



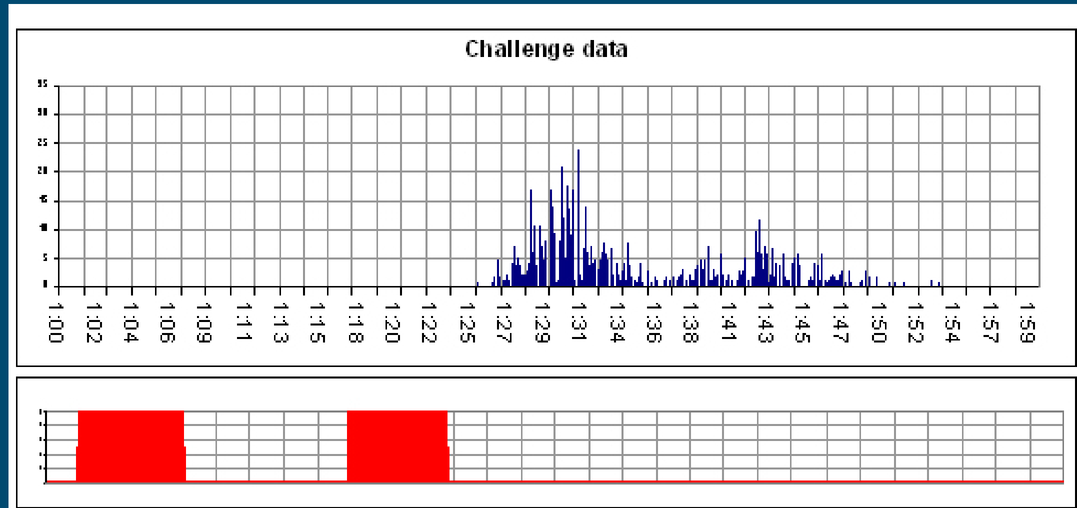
Modelling

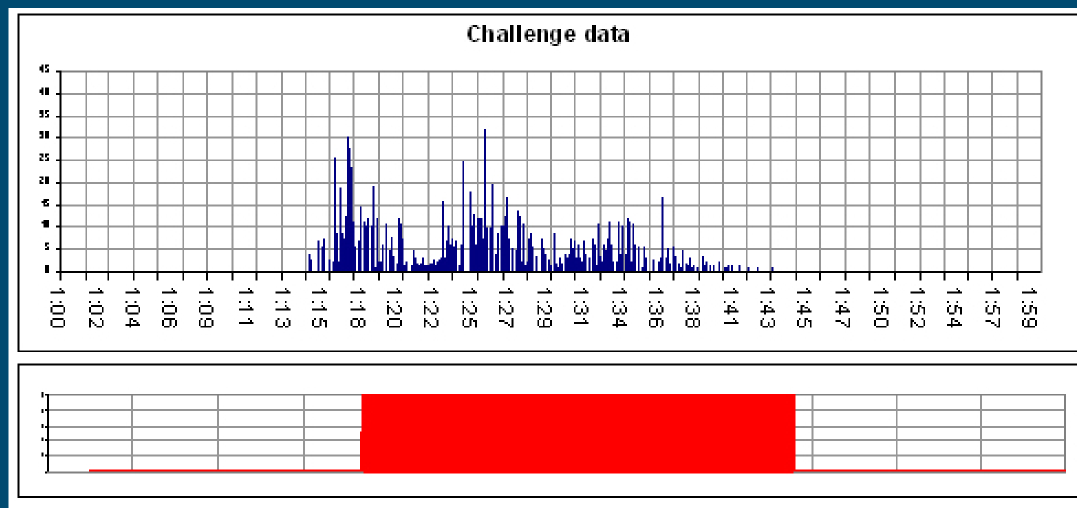
- Meander turbulence model linked with UDM to provide a simulation of meandering plumes
  - required for realistic stimulation of detectors etc.
- Biological background model developed
  - based on field data
- Generic biological detector models developed
  - include measurement noise and sampling noise





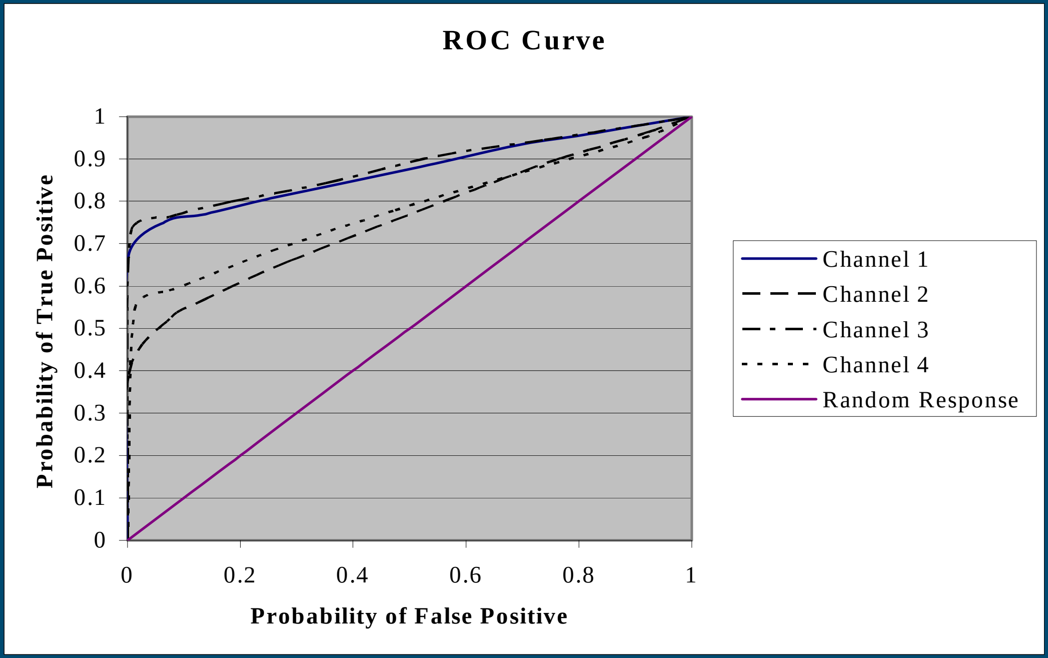
Outcome





- Successful study
  - Scored systems objectively
  - Guided number of sensors required
  - Assessed performance in difficult environments (rural, urban)

Sensor Networking



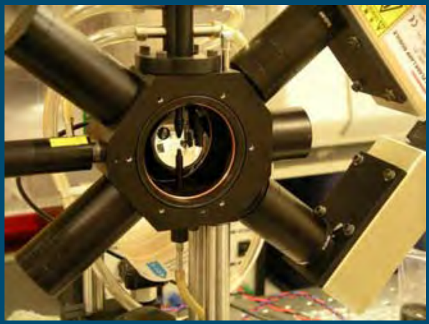
- Last year looked at networking WIBS1 sensors using GARCH
- WIBS1 network not sensitive enough but GARCH improved performance
- Plan to extend to other sensors and evaluate new and existing network fusion algorithms in the CBVB

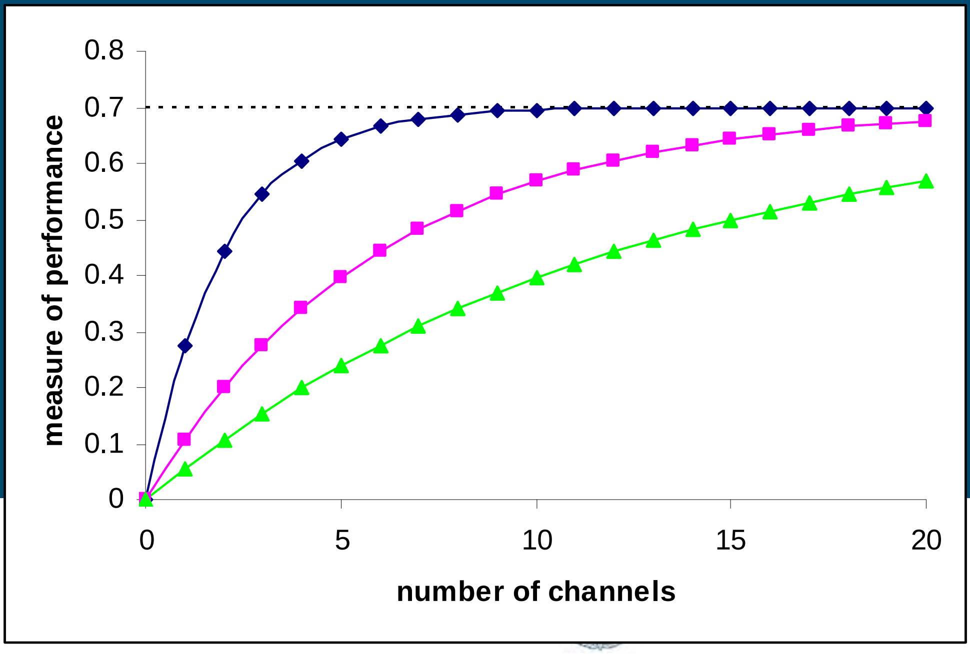
Task 1 – Improve ISMS Network Fusion

- ISMS uses the Biral VeroTect generic sensor & very simple network fusion algorithms
- GARCH network fusion algorithm shown to be effective on WIBS1
- Compare effectiveness of ISMS algorithm and GARCH against model of VeroTect
- Results to feed into ISMS incremental update in March '07

Task 2 – Find Optimal Generic Detector

- Lots of different generic detector prototypes
- How much size, shape and fluorescence information before we approach maximum performance of a generic detector?





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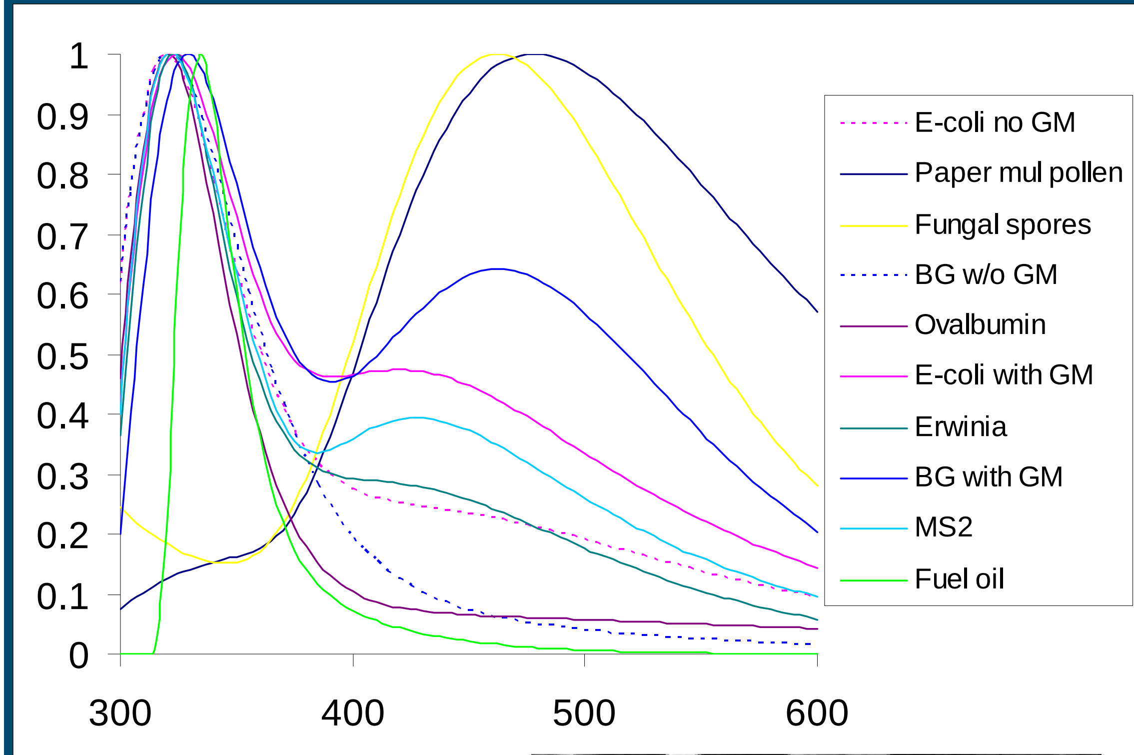
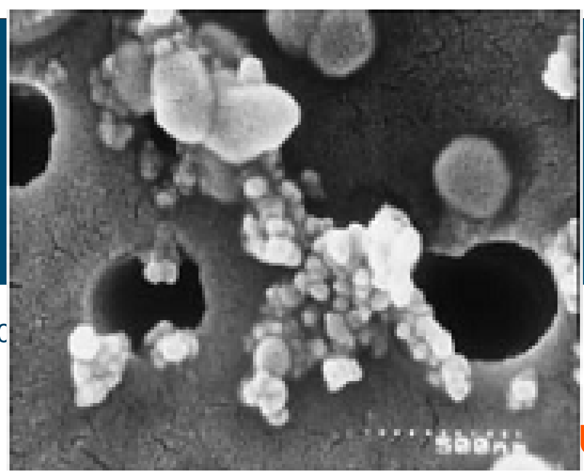
Task 2 – Find Optimal Generic Detector



- Size information important
- Fluorescence spectra contain 2-3 pieces of information
- Bulk fluorescence offers little discrimination – need fluorescence on a particle basis
- Crude shape information required (liquid spheres)



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Aircraft & Aircrew CBRN Survive To Operate

- A large programme to procure CBR protective equipment for aircraft & aircrew
- OA used to determine
  - Is AACSTO necessary?
  - What air capability does AACSTO need to maintain?
  - What hazard levels are be involved in air operations?
  - What is the burden of AACSTO on aircrew?

AACSTO – Phase 1 - 3

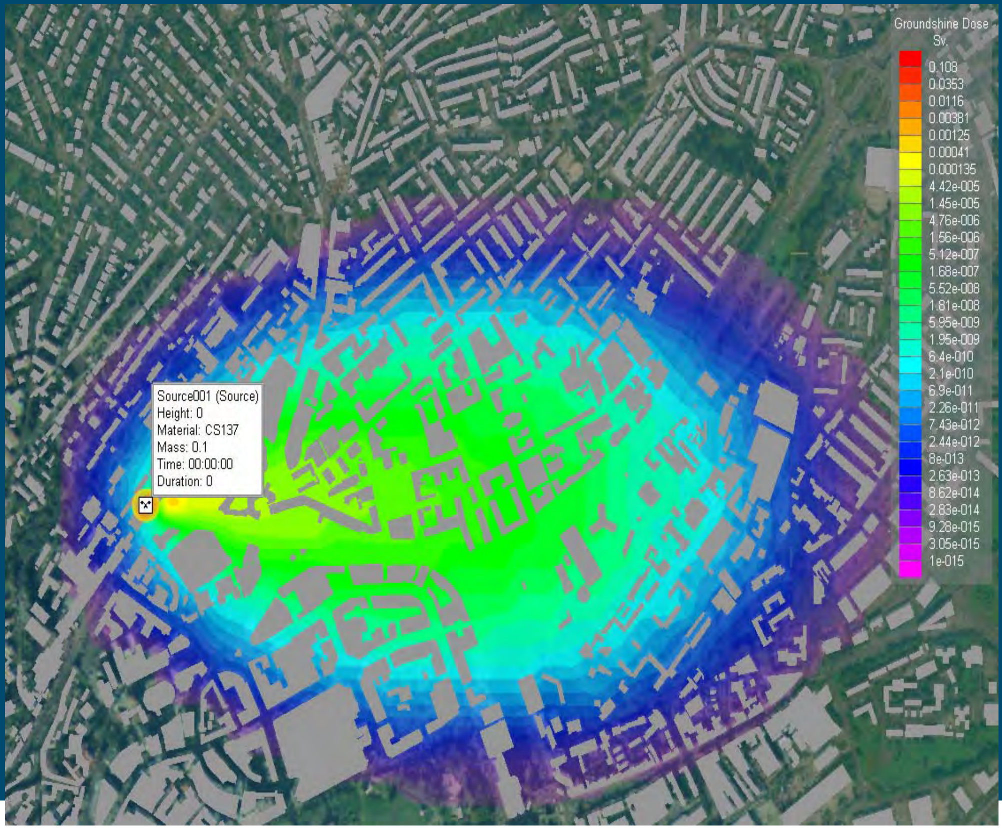
- Phase 1 - Complete
  - Review of existing work undertaken across MOD
  - Concluded that no work tested against comparable threats to those currently faced
- Phase 2 - Ongoing
  - Identify threat scenarios and use of CBRN materials
  - Determine the aircraft involved in these operations and their corresponding missions
  - Identify the concepts & doctrine used to mitigate the use of CBRN
- Phase 3 - Ongoing
  - Series of war-games and workshops to determine the areas in which AACSTO is most necessary

AACSTO - Phase 4

- Two main goals:
  - Quantify the CBR challenge that aircraft and aircrew may be exposed to
  - Determine the thermal load placed upon aircrew and ground-crew by a range of protective ensembles
- We use the aircraft, missions and threat scenarios that are coming out of Phase 2 (running in parallel)

The CBR Virtual Battlespace (CBVB)

- The CBVB is used for the modelling in Phase 4
- New models have been added to the CBVB as part of this work
  - Airframe Model
  - Heat Strain Model
  - Protection Model
  - Radiological Post Processor



Task 1 – Draw up Mission Profiles

- Mission Profiles will include
  - Activity level (Watts)
  - Waypoints that describe route taken (either absolute or offset via velocity and start point (x,y,z,t))
  - Type of clothing represented as a protection factor and thermal and vapour resistances
  - Local environmental conditions, including temperature, winds & stability
- Take into account different phases:
  - Aircrew at rest on airbase
  - Transference to air platform
  - Take off
  - Level flight at representative height
  - Landing

Task 2 – Safe Core Temperature

- Do mission profiles from Task 1 result in safe core temperatures?
- The Heat Strain Model
  - Based on US SCENARIO model, but improved
  - Now passed V&V testing
  - Is being compared against other models
    - USARIEM model
    - DSTO Werner/Lotens model
    - QinetiQ model
  - Also compared against experimental data

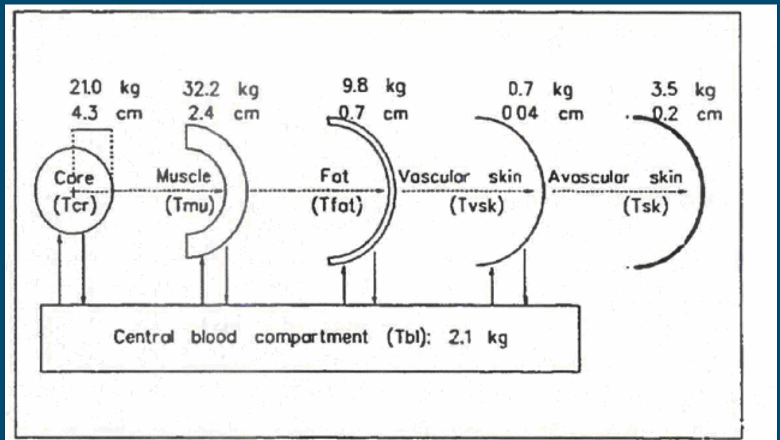
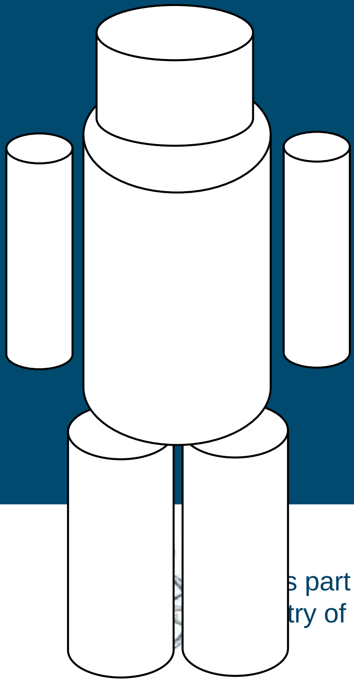


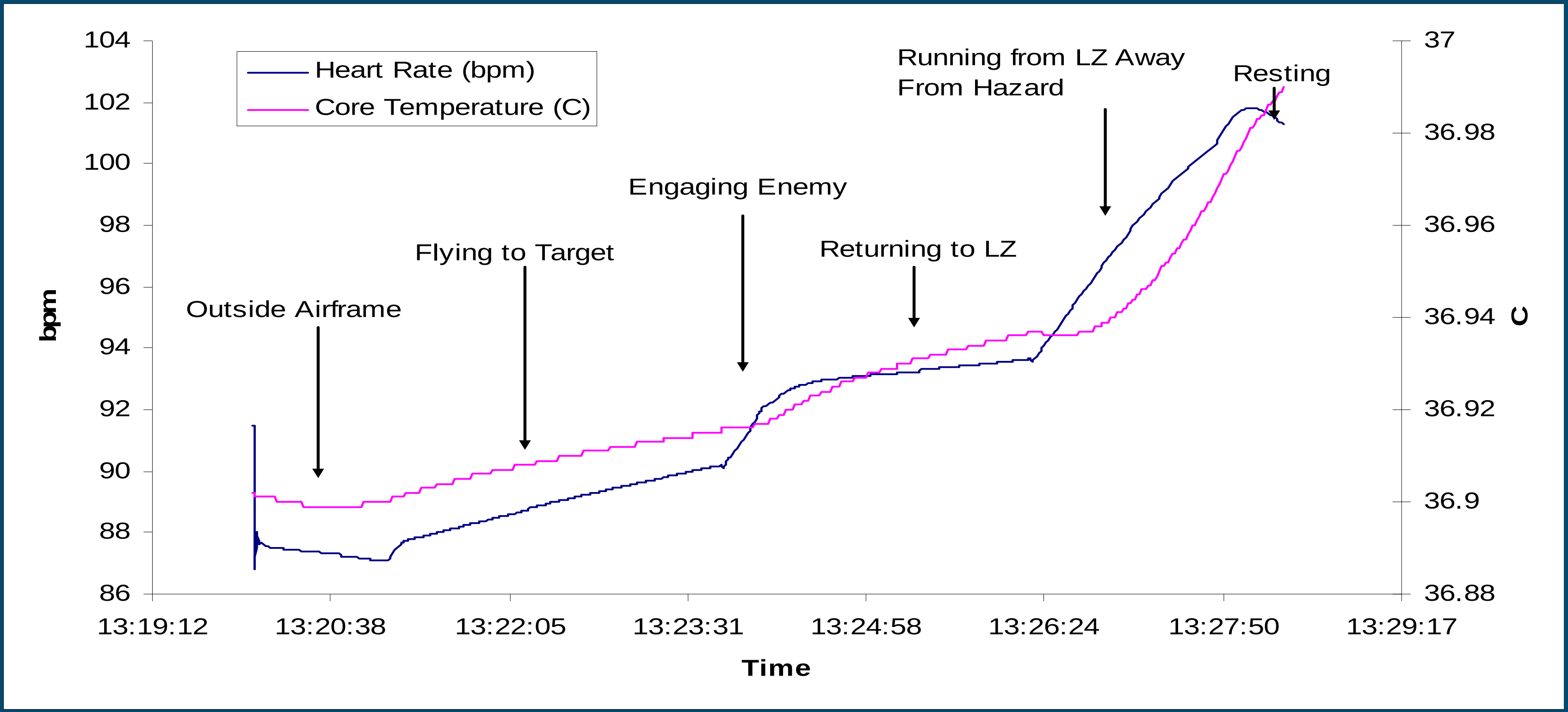
Figure 1. Cross-section of cylindrical model containing 5 concentric annular tissue compartments. Dimensions are for an individual with $W = 70$ kg, $A_D = 1.8$ m^2.



Task 2 – Safe Core Temperature

- The Airframe Model
  - Estimates the environmental conditions inside aircraft (radiant and ambient temperature, humidity & wind-speed)
  - Based on lit search of past trial data & simple atmospheric physics
  - Now integrated into the CBVB
- CBVB can calculate the heat strain associated with current and prototype clothing ensembles
  - Drive future clothing research

Task 2 – Safe Core Temperature



Task 3 – Determine CBR Challenge

- The Protection Model
  - New model to determine the protection factors provided by various types of aircraft now integrated into CBVB
- Predict the CBR hazard to the platforms at various times during the mission profiles:
  - Given that a CBR event is intercepted, determine if a high or low burden protection option is required, and when during the mission it is needed
- Mission profiles from Task 1 against current threat scenarios
  - Use of agent, weapon system and target will be derived from CBR planning scenario development work
  - Meteorological data specific to the location
- Challenge model runs completed for helicopters – fast jet and fixed wing runs underway.

Conclusions

- The Virtual Battlespace has been successfully used to support the acquisition process
  - Used to both test and evaluate existing capability and drive research in new areas
  - Significantly improved capability (includes casualty chain, effects on operations)
  - Widely used (2004-05 – 1 study; 2006-07 – 5 studies)
    - Every study improves VB, benefiting subsequent studies
  - International
    - New TTCP CBR Group AG
    - DSTO involvement

Department of Defense Chemical Biological Defense Program

COL David Jarrett, MC, USA
Deputy and Medical Director,
Office of the Special Assistant for Chemical and Biological Defense and Chemical Demilitarization Programs, SA(CBD&CDP)

NDIA Chemical Biological Information Systems
January 9, 2007

CBDP Vision and Mission

VISION

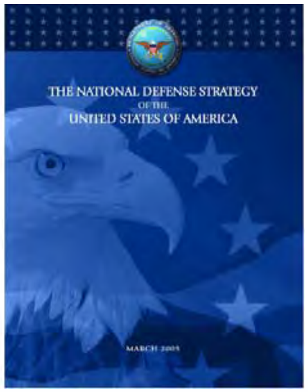
Ensure DOD operations are unconstrained by chemical and biological effects.

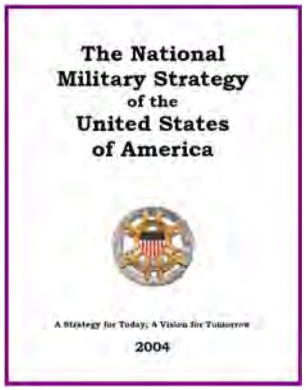
MISSION

Provide chemical and biological defense capabilities in support of the National Military Strategies.

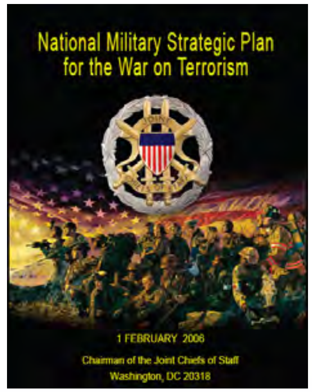
The CBDP Provides Key Capabilities Supporting Multiple National Strategies

National Security

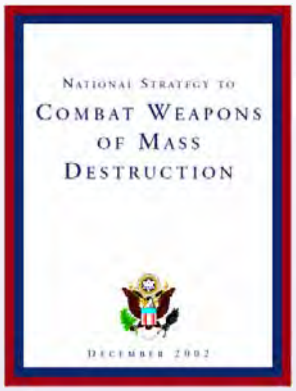


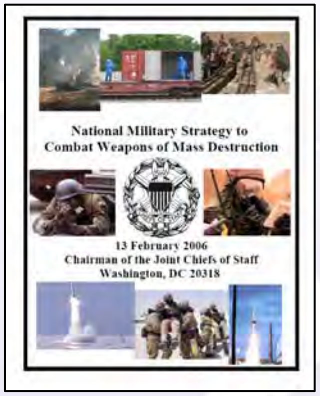


Combating Terrorism

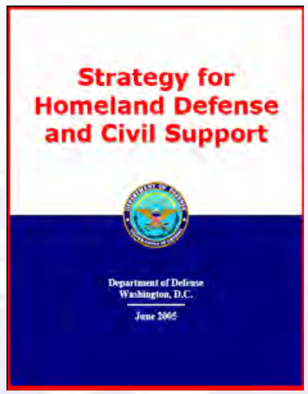


Combating WMD

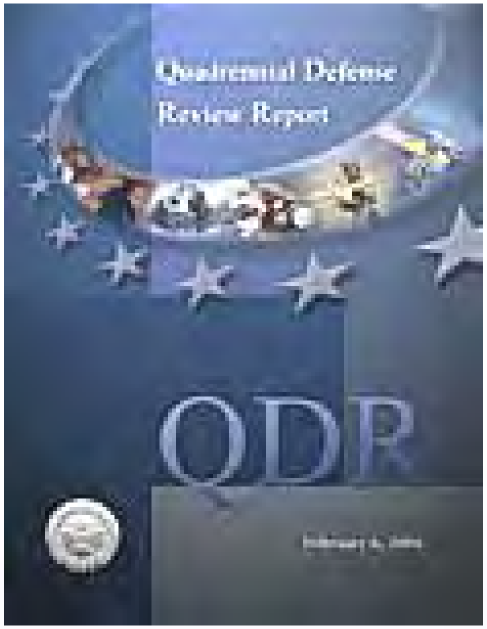




Homeland Security/Defense



Quadrennial Defense Review:
Vision for Combating Weapons of Mass Destruction (WMD)



- **The future force will be organized, trained, equipped, and resourced to deal with all aspects of the threat posed by weapons of mass destruction. It will have capabilities to:**
  - Detect WMD, including fissile material at stand-off ranges;
  - Locate and characterize threats;
  - Interdict WMD and related shipments whether on land, at sea, or in the air;
  - Sustain operations under WMD attack; and
  - Render safe or otherwise eliminate WMD before, during or after a conflict.

- **The Department will develop new defensive capabilities in anticipation of the continued evolution of WMD threats. Such threats include genetically engineered biological pathogens, and next generation chemical agents. The Department will be prepared to respond to and help other agencies to mitigate the consequences of WMD attacks.**

Quadrennial Defense Review:

Implementing the Combating WMD Vision

- **To achieve the characteristics of the future joint force the Department will:**
  - Designate DTRA to be the primary Combat Support Agency for U.S. Strategic Command in its role as lead combatant commander for integrating and synchronizing combating WMD efforts.
    - *Initial Operational Capability announced January 26, 2006*
  - Expand Army's 20th Support Command (CBRNE) capabilities to enable it to serve as a Joint Task Force capable of rapid deployment to command and control WMD elimination and site exploitation missions by 2007.
    - *Full Operational Capability expected September 2007*
  - Reallocate funding within the CBDP to **invest more than $1.5 billion** over the next five years to **develop broad-spectrum medical countermeasures** against advanced bio-terror threats, including genetically engineered intracellular bacterial pathogens and hemorrhagic fevers.
    - *Funding reallocated*
    - *FY06 contracts awarded*
    - *FY07 proposals under review (initial proposal phase completed in December 2006)*

DOD CBDP Background

- **Established by Congress**
  - Fiscal Year 1994 National Defense Authorization Act, Public Law 103-160, Sect. 1703 (50 USC 1522)
- **Consolidates all DOD CB defense efforts into defense-wide funding accounts overseen by a single office within the Office of the Secretary of Defense**
- **Integrates**
  - All research, development, acquisition funds
  - Medical and non-medical funds
- **…but**
  - Operations & Maintenance funds (retained in Service POMs)
  - Military Construction (MILCON) currently funded by the Services and Defense Health Program
  - DARPA programs and funding appear in DARPA POM
- **Closely coordinate with DARPA CB Defense Efforts**
  - Eliminate redundancy and duplication, and support technology transition
- **Memorandum by Under Secretary of Defense for Acquisition, Technology, & Logistics (USD(AT&L)) re-organized on April 22, 2003 (updated July 10, 2006)**
  - USD(AT&L) oversees through Overarching Integrated Process Team
  - Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD) as single Milestone Decision Authority (MDA) (*Replaced nine separate MDAs*)
  - Defense Threat Reduction Agency (DTRA) established as Joint Science & Technology Office for CBD
  - JRO-CBRND established as focal point within Joint Staff
  - Scope expanded to specifically include radiological defense

ATSD(NCB) Provides Oversight of the Program

CBDP Process

- Combatant Commanders
- Services

ATSD(NCB) Oversight

Required Capabilities

Joint Requirements Office (JRO)

Capability Needs

Prioritized Needs

Joint Test & Evaluation Executive

Joint Combat Developer

Joint Science & Technology Office for CB Defense

Science &Tech Gaps

Joint Program Executive Office (JPEO)

Mature Technologies

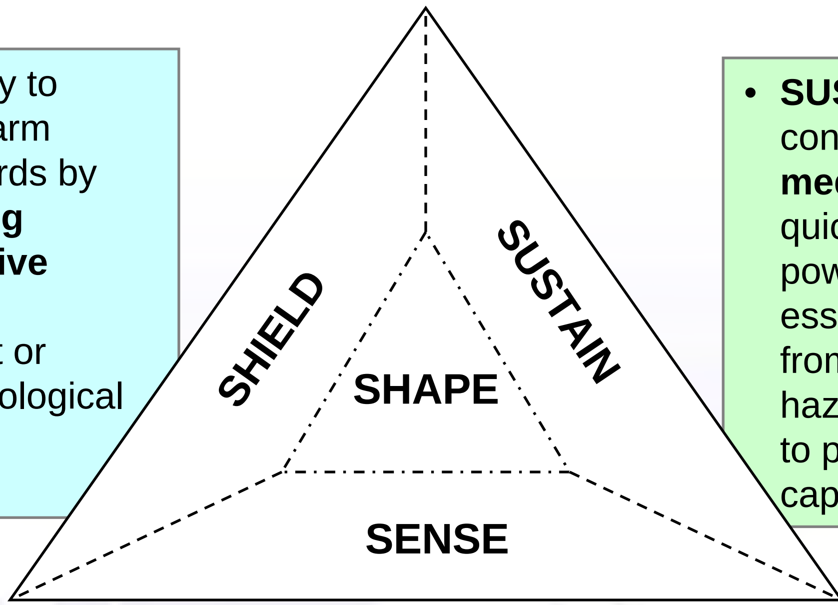
Capabilities to the Warfighter for All Missions

Process based on managing total program risk

Joint CBRN Defense Functional Concept – Operational Attributes

- **SHAPE –** Provides the ability to **characterize the CBRN hazard** to the force commander - develop a clear understanding of the current and predicted CBRN situation; collect, query, and assimilate info from sensors, intelligence, medical, etc., in near real time to inform personnel, **provide actual and potential impacts of CBRN hazards**; envision critical SENSE, SHIELD and SUSTAIN end states (preparation for operations); visualize the sequence of events that moves the force from its current state to those end states.

- **SHIELD –**The capability to shield the force from harm caused by CBRN hazards by **preventing or reducing individual and collective exposures**, applying **prophylaxis** to prevent or mitigate negative physiological effects, and protecting critical equipment



- **SUSTAIN –** The ability to conduct **decontamination** and **medical** actions that enable the quick restoration of combat power, maintain/recover essential functions that are free from the effects of CBRN hazards, and facilitate the return to pre-incident operational capability as soon as possible.

- **SENSE –** The capability to continually provide the information about the CBRN situation at a time and place by **detecting, identifying, and quantifying** CBRN hazards in air, water, on land, on personnel, equipment or facilities. This capability includes detecting, identifying, and quantifying those CBRN hazards in all physical states (solid, liquid, gas).

Selected CBD Systems

SENSE

Joint Bio Point Detection System (JBPDS)

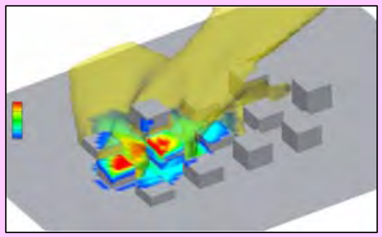
Joint Bio Standoff Detection System (JBSDS)

NBCRV

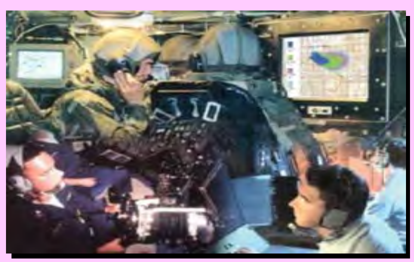
JCAD

SHAPE

Joint Warning and Reporting Network



Joint Effects Model (JEM)



Joint Operations Effects Federation (JOEF)

SHIELD

Joint Vaccine Acquisition Program

JSLIST

JSGPM

CB Protected Shelter

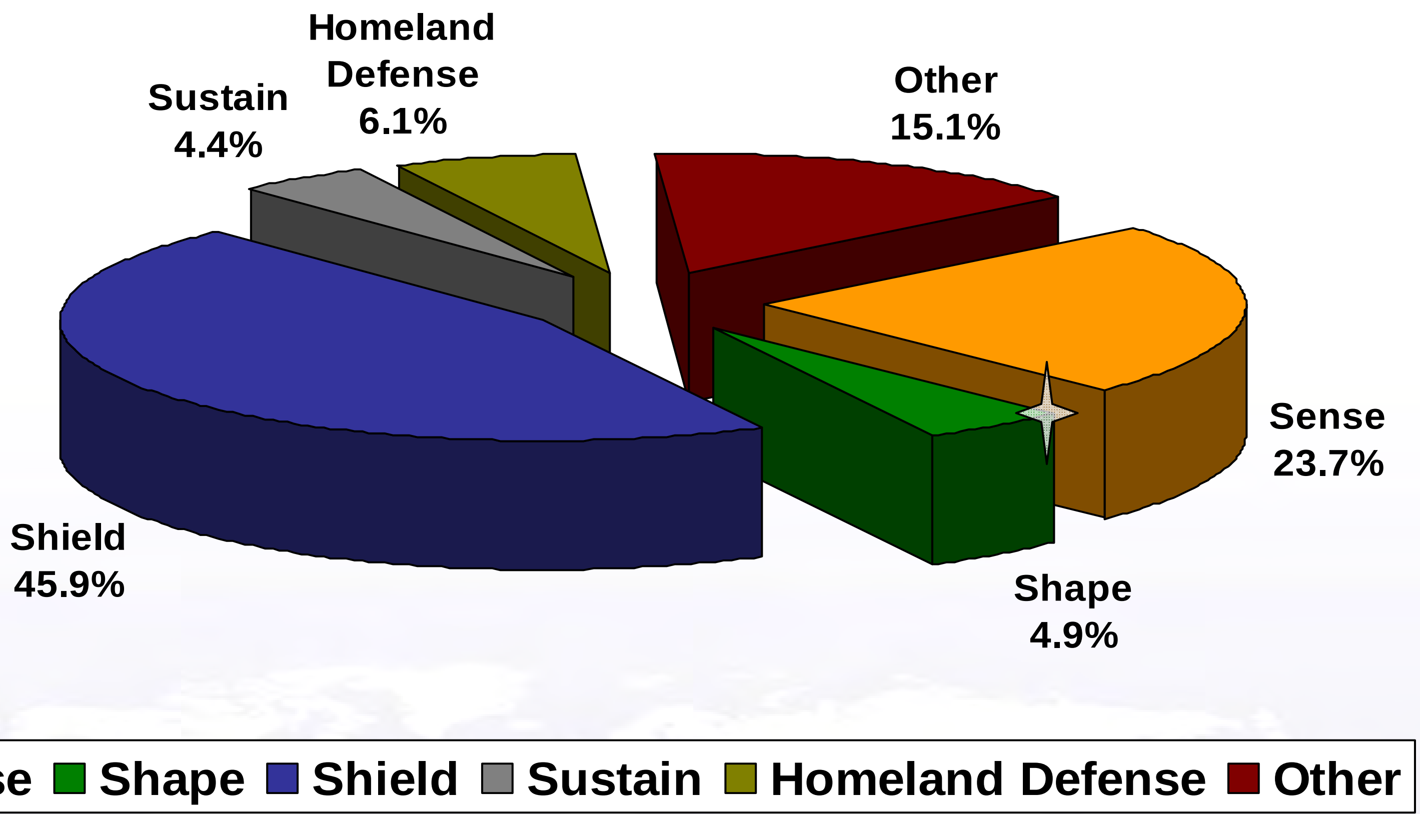
SUSTAIN

Joint Bio Agent Identification & Diagnostic System (JBAIDS)

Antidote Treatment, Nerve Agent Autoinjector (ATNAA)

Joint Service Transportable Decon System

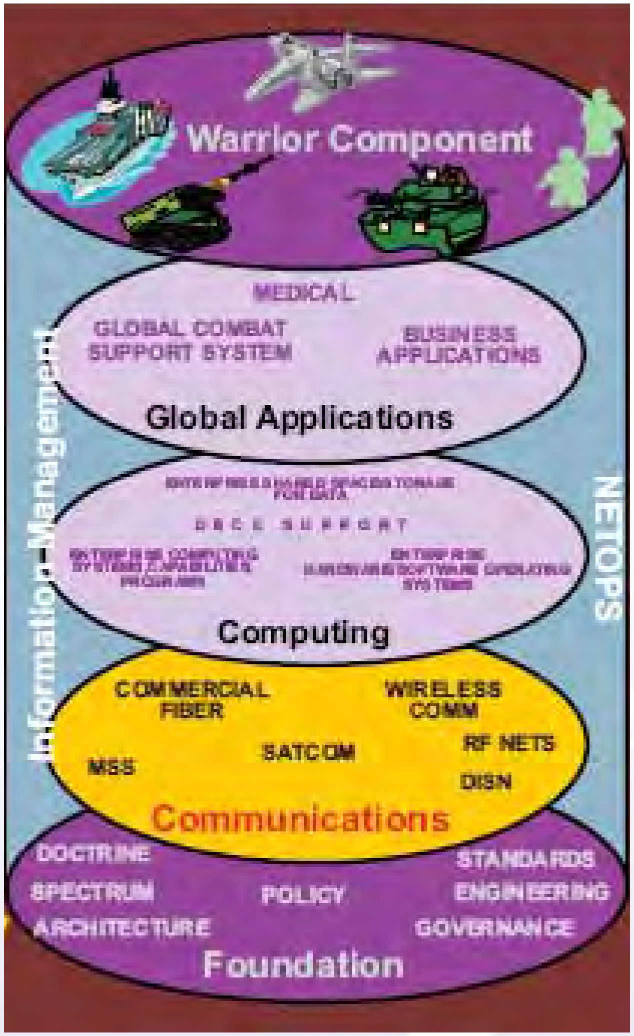
FY07 President's Budget (PB)*
Capability Areas



Total Funding FY07: $1.504B

* Based on FY07 National Defense Appropriations Act (Public Law 109-289)

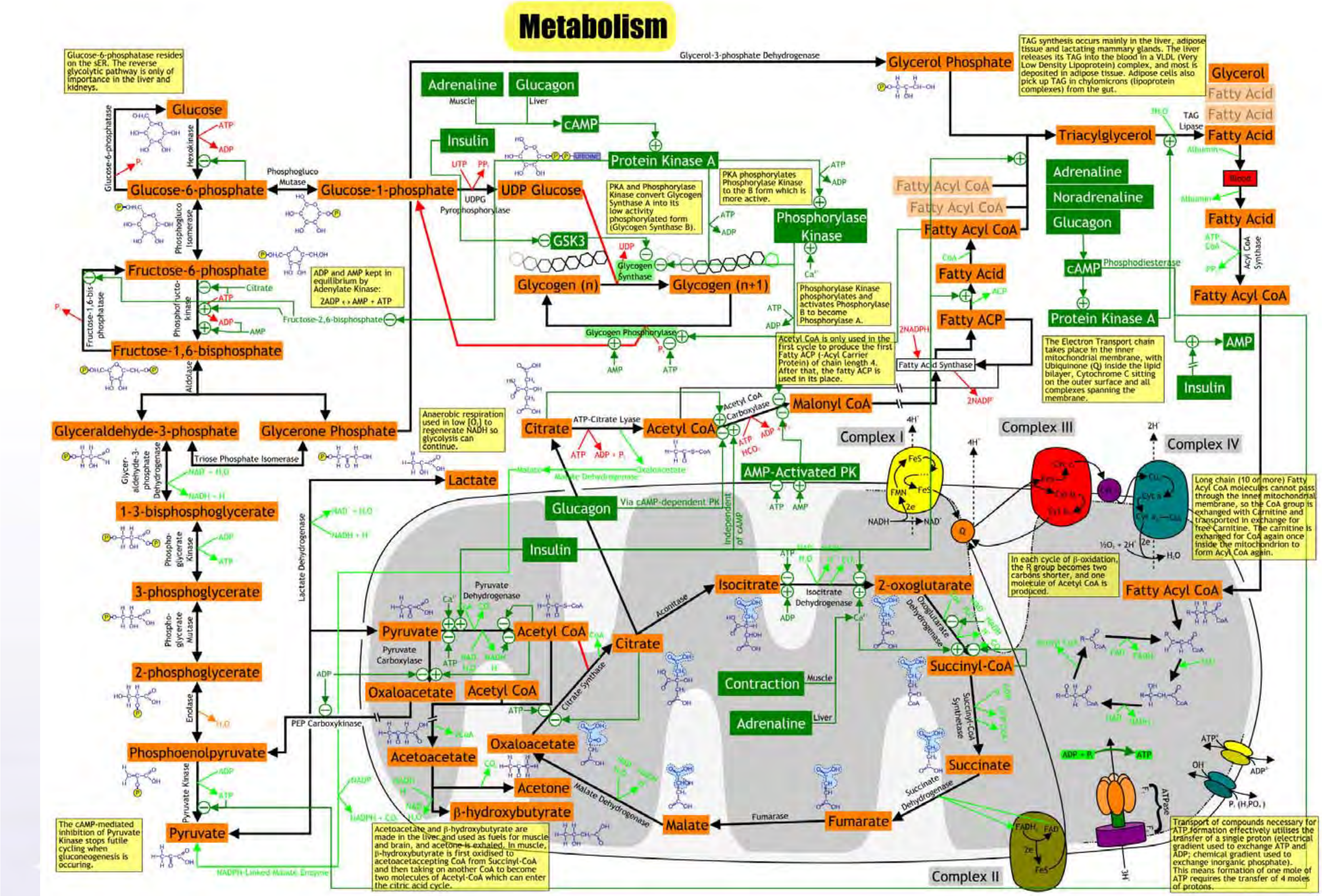
Information Systems will be key to success of DoD Operations <u>Globally</u>



"A networked Joint Force is able to maintain a more accurate presentation of the battlespace built on the ability to integrate intelligence, surveillance and reconnaissance, information and total asset visibility. This integrated picture allows the JFC to better employ the right capabilities, at the right place and at the right time."

Department of Defense, Joint Operations Concepts, November 2003

Information systems will be key to the success of capabilities at a <u>genetic</u> level



The Future CBRN Warfighter

The challenge for Information Systems will be the total integration of defense capabilities into a joint capability portfolio

New Technologies for New Threats

- **Traditional technologies may not defeat advanced threats.**
  - **Currently licensed vaccines for biodefense are not substantially more effective than those developed by Edward Jenner in the 18th century.**
- **Research and Development efforts must evolve with the threat.**
  - **Develop hardware/platforms for both military and civilian use.**
  - **Variants are distinguishable by platform, and software modifications: *Common technologies – different platforms*.**
  - **Establishment of Standards are crucial but the traditional physical model may not provide the best solution.**
    - **For detection, approach needs to be sliding scale that optimizes sensitivity, probability of detection, false positive rate, and response time, known as ROC (Receiver Operating Characteristic) Curves.**
- **Leverage private sector to transform WMD protection and defeat capabilities to leapfrog WMD threat generations.**

CBDP Science & Technology (S&T) Initiatives

- **Identify and Exploit Revolutionary Technologies**
  - Transformational Medical Technologies Initiative (TMTI)
  - Transformational Countermeasures Technology Initiative (TCTI)
  - Nanotechnology Initiative
- **Recapitalization of S&T Infrastructure**
  - Test & Evaluation Facilities
  - NTA Test Chamber
  - U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) Recapitalization

Initiatives will enhance CBD S&T capabilities.

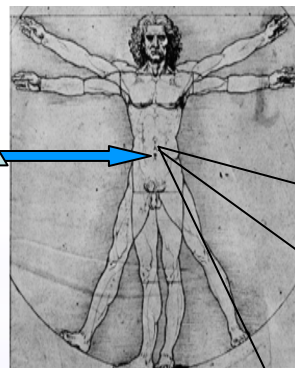
Transformational Medical Technology Initiative (TMTI)

Medical Countermeasures Against Advanced Bio Threats

Today's Threats

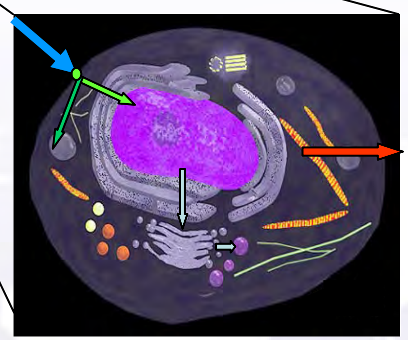
- *Anthrax*
- *Smallpox*
- *Botulinum*
- *Plague*
- *Tularemia*
- *Ebola/Filo*
- *Hemorrhagic Fever*
- *Encephalitis*
- *SARS*
- *Influenza*
- *Ricin/SEB, others*

Bioengineered



Modes of Action

- *Receptor Binding*
- *Signal Transduction*
- *Decoys*
- *Immune Avoidance*
- *Translation/Transcription*
- *Immune Deregulation*
- *Replication*
- *Virulence Expression*



Parallel Systems Approach

Solutions

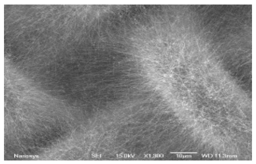
Target Agent Commonalities

- Block Key Receptors
- Inhibition by Small Molecules
- Modulate Immunity
- Change Gene Expression
- Block Protein Actions
- Modulate Physiologic Impacts

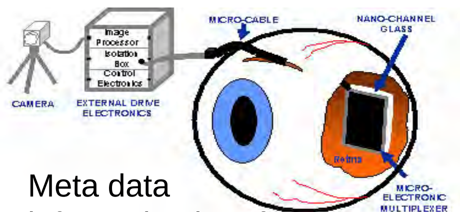
One *PIECE* at a time → Process Analysis → Broad Spectrum

Transformational Countermeasures Technology Initiative (TCTI)

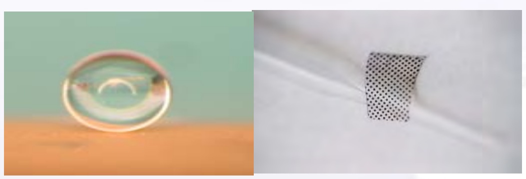
Basic Science Advances → **Integrated Cross-Cutting Technologies** → **Broad Spectrum Application**


Nano-catalytic self-decon material


Bio-engineered materials



Meta data information interface


Nano-scale protective coatings and fabrics

- Multi-threat defense
- Integral design concept
- Interactive digital multi-faceted data architecture

Nanotechnology, Biotechnology, Information Technology (IT), and Cognitive Sciences (NBIC)


Future Combat System

- Hierarchical systems of systems
- Non-intrusive minimal logistics


Consequence Management

Develops revolutionary technologies that provide the warfighter with a fully integrated protective ensemble.

Nanotechnology Initiative

Joint Science & Technology Office (JSTO) nanotechnology initiative is a two-phased effort.

Phase I

- **Objective:** Conduct a survey of nanotechnologies with application to CBD needs.
- Team from MIT-LL and Natick Soldier Center will conduct the survey.
- Recommendations will be provided to JSTO on applicable nanotechnologies.

National Nanotechnology Activities

Materials

Sensors

Quantum dots

Fabrics

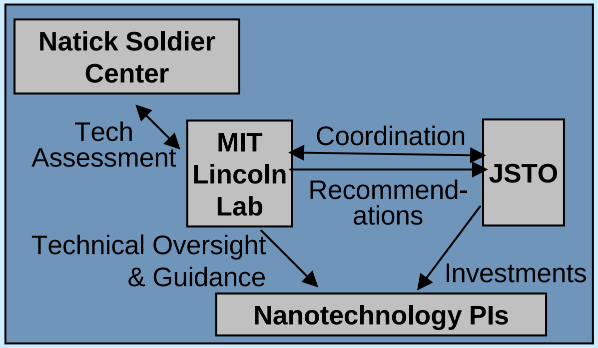
Nanostructures

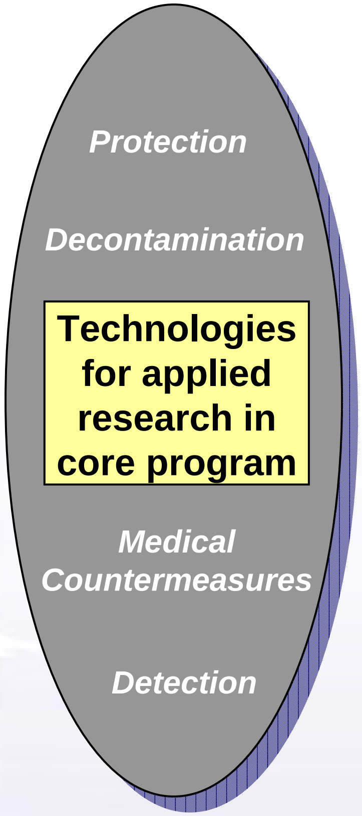
Therapeutics

Catalysts

Phase II

- **Objective:** Develop a solid S&T base of nanotechnology applied to all aspects of CBD needs.
- Multidisciplinary team will advise nanotechnology program Principal Investigators (PIs).
- Nanotechnology developments will continue to be monitored.





Leverages significant interagency investments for potential CBD applications.

Recapitalization of S&T Infrastructure

- **Initiative underway to recapitalize and revitalize CBD S&T infrastructure, which is required to:**
  - Counter expanding threats from novel and emerging threats.
  - Exploit advances in technology.
  - Speed the technology transition into systems acquisition programs.

U.S. Army Medical Research Institute of Infectious Diseases

Exterior

BL-4 Lab

Edgewood Chemical Biological Center's Advanced Chemistry Lab

Lab Exterior

Filtration System

Lab Interior

Leveraging Interagency Activities are Key to Achieving National Strategies

CBDP Coordinates With:

Counterproliferation Program Review Committee (CPRC)

Technical Support Working Group (TSWG)

U.S. Coast Guard

Centers for Disease Control (CDC)

National Institute of Allergies and Infectious Diseases (NIAID)

Department of Homeland Security (DHS), S&T Directorate

Various Levels of Coordination/Cooperation Exist With:

U.S. Department of Agriculture (USDA)

Department of Health and Human Services (DHHS)

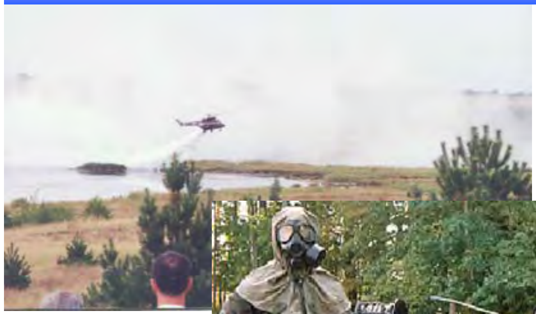
Office of Science & Technology Policy

Department of Justice

National Security Council (NSC)

International Partnerships are Leveraged to Support of Phases of CB Defense

Foreign Comparative Testing



MOUs & MOAs

Cooperative Research and Development

Foreign Military Sales

Cooperative Production

Exchange of Personnel

Loans

Exchange of Information

CBDP: The Way Ahead

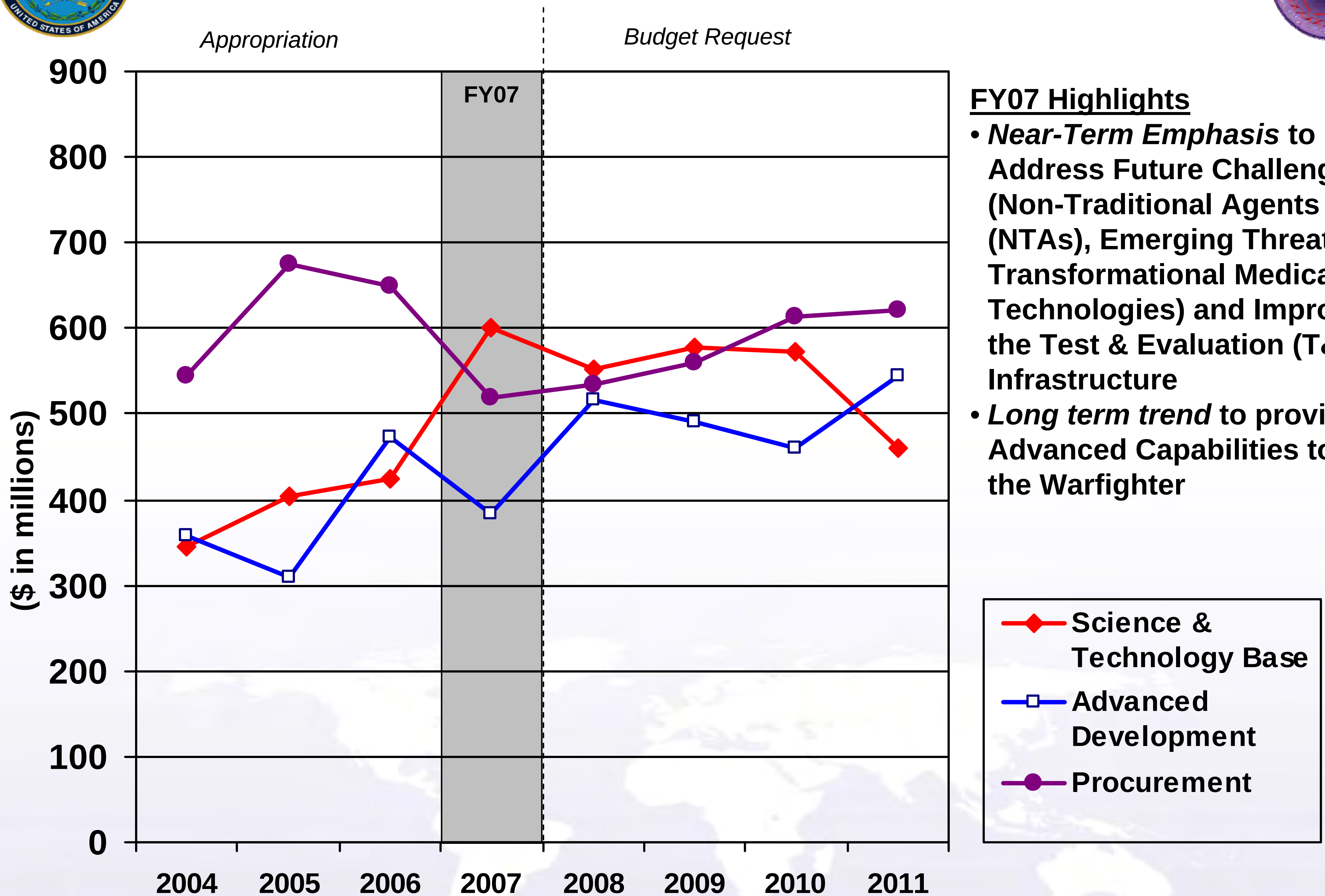
- **Need to build on current strengths…**
  - Integrated portfolio of capabilities supporting critical operational missions.
  - Multi-disciplinary approaches.
  - Well developed doctrine and concepts for the military in operational environments.
- **…while recognizing a changing environment…**
  - Laboratory and other infrastructure need overhaul.
  - Operational environment must consider homeland.
    - DOD now a key player, but no longer the biggest investment.
  - Emerging and non-traditional threats may be critical.
  - Congress will continue to play an active role.
  - Industry is increasingly important, though DOD-unique assets need to be identified and maintained.

CBDP: The Way Ahead

- **…and Planning for the Future.**
  - Need to balance investment between:
    - Current risks (operational and procurement needs); and
    - Future risks (S&T and infrastructure).
  - Coordination with other agencies (DHHS, DHS, and others) for an effective national effort.
    - DOD may play key role in transitioning technologies from laboratory concepts to field-ready systems, especially medical systems.
  - Broad-spectrum, dual-benefit approaches will need to be evaluated in all areas.

Questions

FY07 President's Budget *

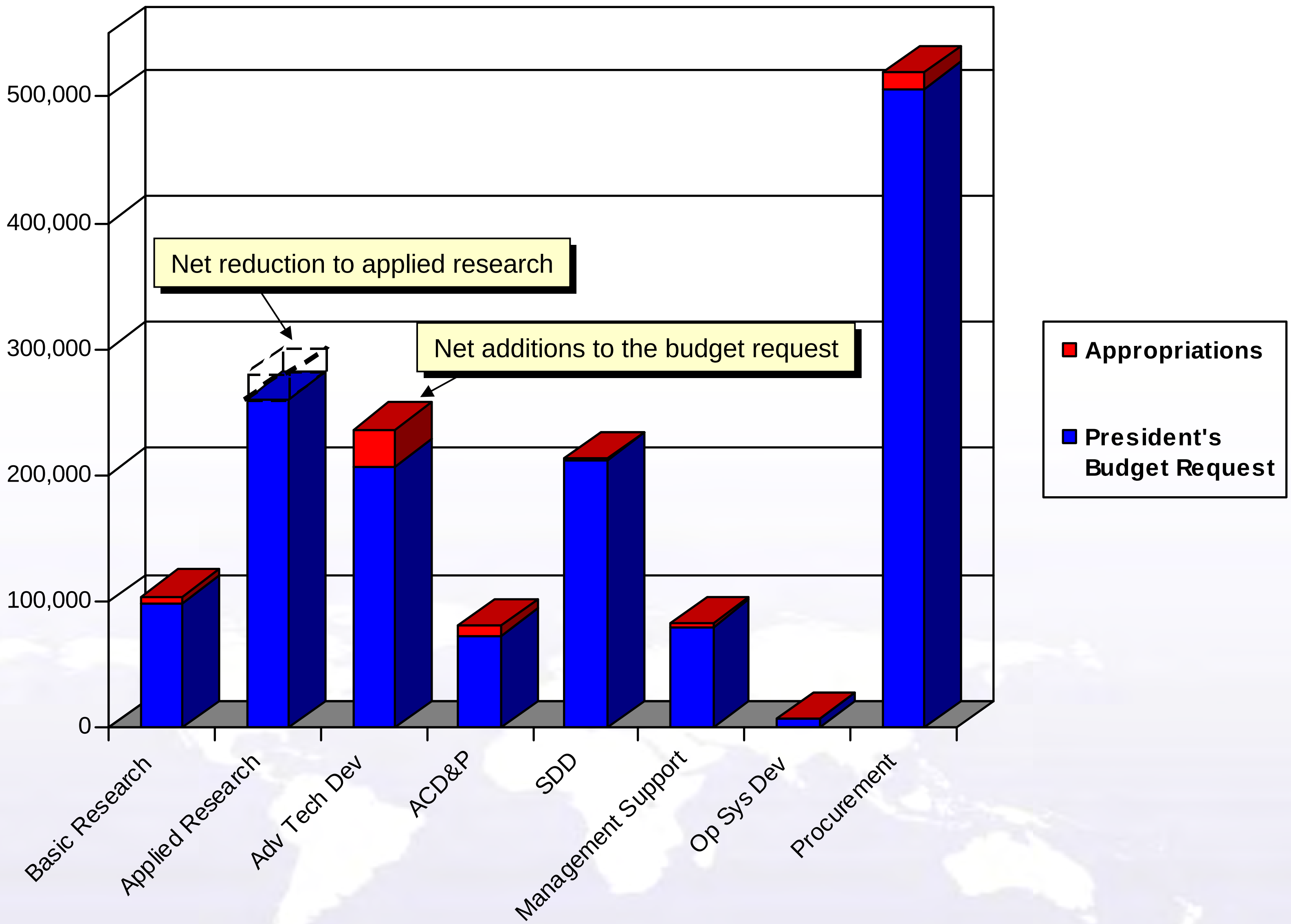


<u>FY07 Highlights</u>

- ***Near-Term Emphasis*** **to Address Future Challenges (Non-Traditional Agents (NTAs), Emerging Threats, Transformational Medical Technologies) and Improve the Test & Evaluation (T&E) Infrastructure**
- ***Long term trend*** **to provide Advanced Capabilities to the Warfighter**

* Based on FY07 Defense Appropriations Act (Public Law 109-289)

FY07 Chemical Biological Defense Program Summary



* Based on FY07 Defense Appropriations Act (Public Law 109-289)

UNCLASSIFIED

Wanted: Revolutionary Advances in CBRN Information Systems

January 9, 2007

PRESENTED TO:
2007 CBIS Conference
Austin, TX

DOUGLAS W. BRYCE
Deputy Joint Program Executive Officer
for Chemical and Biological Defense
(703) 681-9600

Distribution Statement A: Approved for Public Release

Joint Program Executive Office
Future Vision

In order to transform the current paradigm of incremental improvements, we need to leap ahead and embrace truly revolutionary, integrated and cross-cutting technologies by leveraging current advances in the *Nanotechnology-Biotechnology-Information Technology-Cognitive and Materials S*ciences.

Materials Science - integrated across platforms, including the individual, is a key element in the CBDP system of systems strategy.

"A hiatus exists between the inventor who knows what they could invent, if they only knew what was wanted, and the soldiers who knew, or ought to know, what they want and would ask for it if they only knew how much science could do for them. You have never really bridged that gap yet."

Winston Churchill
The Great War, Vol. 4

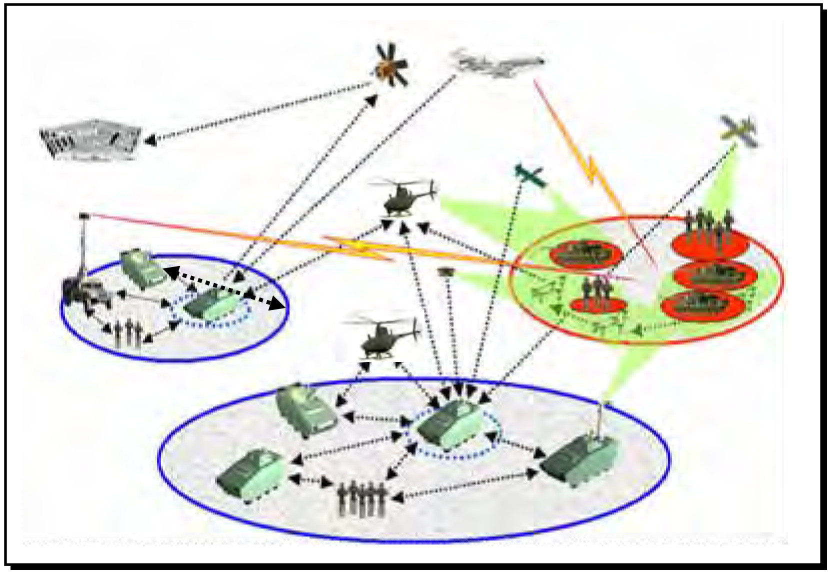
Technology Trends and Cycles

Primary Structural Materials →	20 - 40 Years
Propulsion →	15 - 25 Years
Weapons →	8 - 15 Years
Sensors →	3 - 8 Years
Stealth Concepts →	3 - 5 Years
Communications →	1 - 3 Years
IT Software →	1.5 - 2 Years
IT Components →	.5 – 1 Years

- Globally Available Technology
- Our Technological Advantage Comes From Speed of Systemization

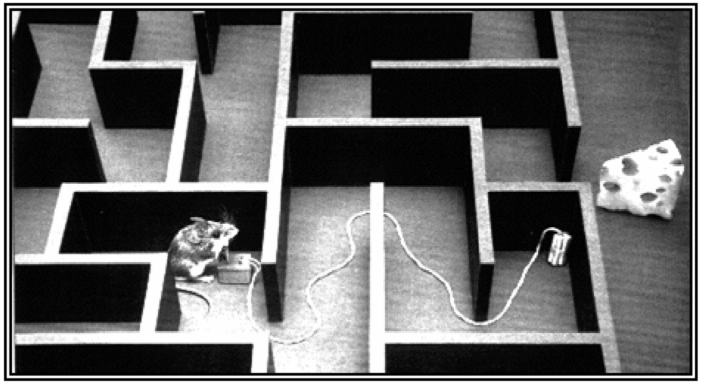
Future of CBRN Defense

- **Net-Centric CB Defense Architecture**
  - **A Family of Integrated Systems (Sensors, Information Systems, Protection Systems, Consequence Management Tools)**
  - **Continual or On-Demand Access to Data Through Various Ports and Peripherals on the Network**
  - **Shared Awareness, Increased Speed of Command, and Self Synchronization**
  - **Interoperable and Seamless Capability that Provides Exponentially Increased Military Benefit to Those Systems/Soldiers that Otherwise Operate Independently**



Operating Philosophy

- Continuous Evolution Transforming the Way Our Enterprise Operates in Carrying Out Our Missions
  - Central to Our Daily Business
  - Take Initiative
  - Take and Accept Risk
- Output Oriented vs. Input Oriented
- Drive Change by
  - Leadership
  - Seizing Opportunities
  - Rapidly Adapting to Changing World Environment and Adversaries
  - Changing Missions
- Use Evolutionary Change to Produce Revolutionary Results



How Do I Get the Cheese?

"Uncertainty Is The Defining Characterstic of Today's Strategic Environment."

Impact Areas

- Systems Approach
  - Survivability
    - Impact: Potential Re-Design of CB Systems (Modularity, Advanced Materials and Applications, Network-centric Approaches)
      - Detection/Identification
      - Protection
      - Decontamination
      - Medical
  - Suitability
    - Impact: Future Force Structures (Who Needs This, Where, and When)
      - Modularity and Tailorability
      - Plug and Play

Impact Areas *(Cont'd)*

- **Effectiveness**
  - **Impact: "All-Hazards" Capabilities**
    - **Expanded Threat Sets (Toxic Industrial Chemicals, Low Volatility Agents, Engineered CB challenges)**
    - **Modularity and Tailorability**
    - **Plug and Play**
  - **Impact: Decision Support**
    - **Service Oriented Architecture**
    - **Data Fusion**
    - **Reach Back Capabilities**
    - **Network-Centric Solutions**
    - **Effective Integration in Communications/Data Architectures**

System of Systems Approach to Ensuring the Capability to Counter the Threat

Sustained Combat Power

CB Threats & Hazards

Agent Delivery

Doses on Target

Downwind Dispersal

Doses Absorbed

Symptoms

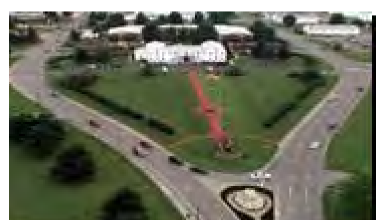
Medical Pretreatment

Individual & Collective Protection

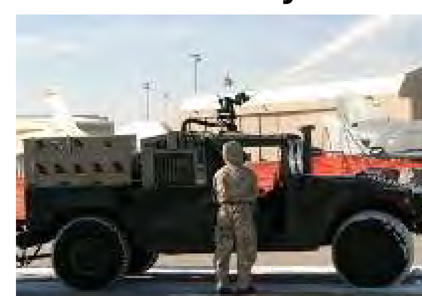
Medical Treatment

Information Systems

Contamination Avoidance and NBC Battle Management (Detection, Identification, Reconnaissance & Warning)

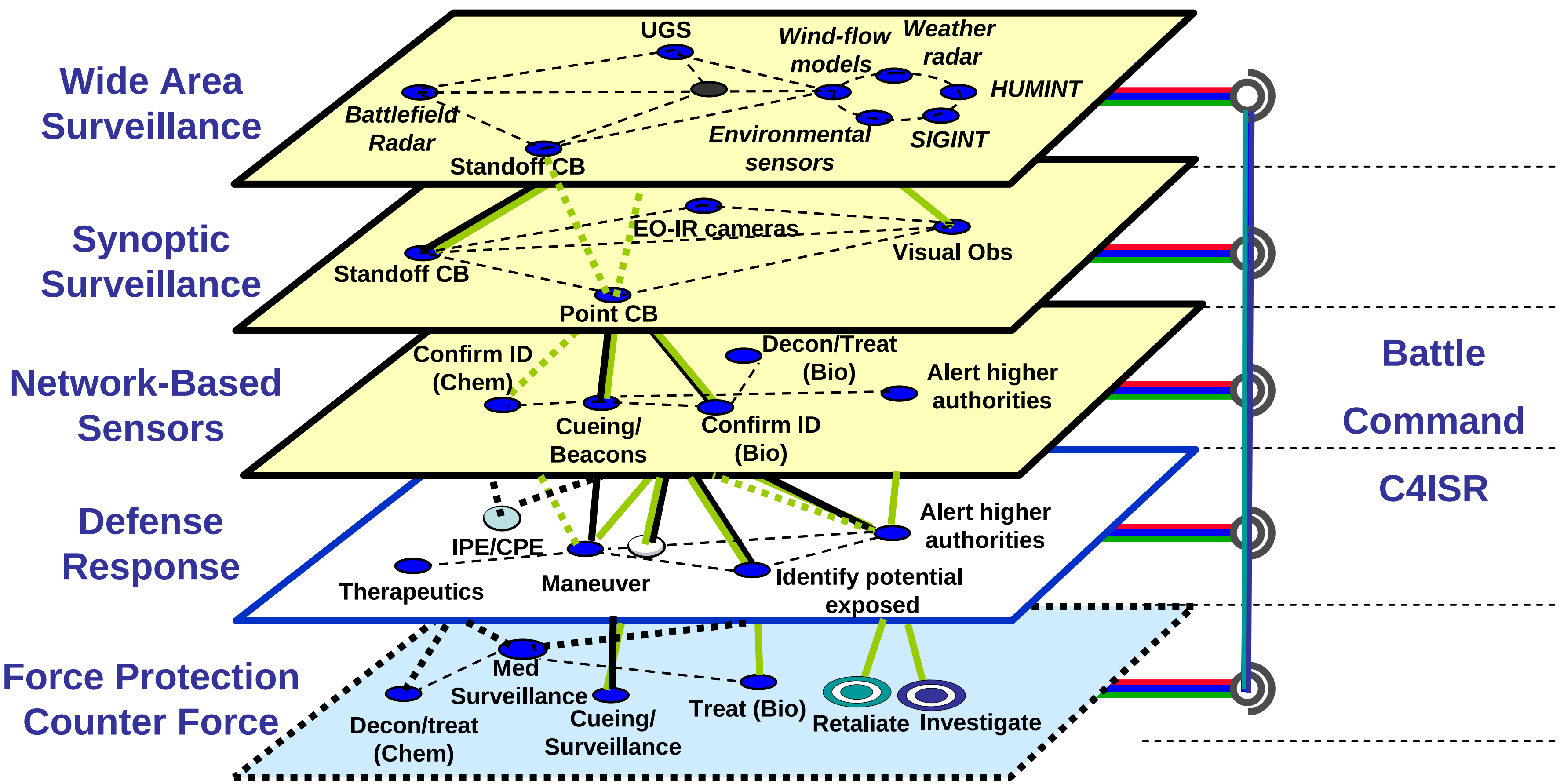


Installation Force Protection



Decontamination, Restoration

Network-Centric Approach Provides Flexible Material Solution Alternatives



Integrated System of Systems Can Provide Improved Situational Awareness and Capability While Easing Component Requirements

Net-Centricity - What's the Problem?

- Current Software Development Process is Not Efficient Enough to Support the Warfighter
  - Can't Keep Up With Technology
  - Can't Keep Up With Changing Warfighter Needs/Rules of Engagement
- Current System Designs Make Reacting to Ever Changing Needs Cost Prohibitive
  - Continuous Code "Face Lifts" are Eating Into Resources
  - Systems Tailored for Particular Platforms are Ill-suited for Distributed Computing
- C2 MDAPs Transitioning to Service Oriented Architectures
  - Tracking and Keeping Up With Changes Across Each Program of Record

Migration to Service Oriented Architectures ROADMAP

As IS — Along the way — To Be

Evolutionary Alignment Efforts

- A Mix of Individual Stove Pipe Systems and COE Mission Applications.
- May or May Not be Net-centric
- Built With a Variety of Technologies on a Variety of Platforms
- Generally Do Not Interoperate
- Never Built With an Enterprise in Mind

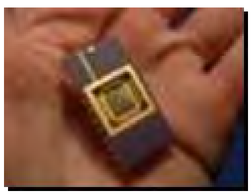
- Technical
  - ✓ Various Connection Strategies, Wrappers and Bridge Approaches
  - ✓ Bridge and Mediation strategies
  - ✓ Multiple Middle ware approaches
  - ✓ Technical Guidance
  - ✓ Migration Strategies
- Organizational/Managerial
  - ✓ Policy and Standards
  - ✓ Acquisition Guidance
  - ✓ Contract Guidance
  - ✓ Requirements
  - ✓ Alignment
  - ✓ Migration Strategies
  - ✓ Doctrine

- Composable Warfighting
  - Rapid Deployment
  - Rapid Integration Environments
  - Support Old and New Threats (Scalability)
  - A Collection of Components and Services
  - Managed Open Architectures and Standards.
  - Capabilities Assembled in a Variety of Ways Supporting the Notion of Dynamic Configuration
    - Composeable
    - Plug & Play
    - Adaptive
    - Security

Modularity Vision – A Plug & Play CB System

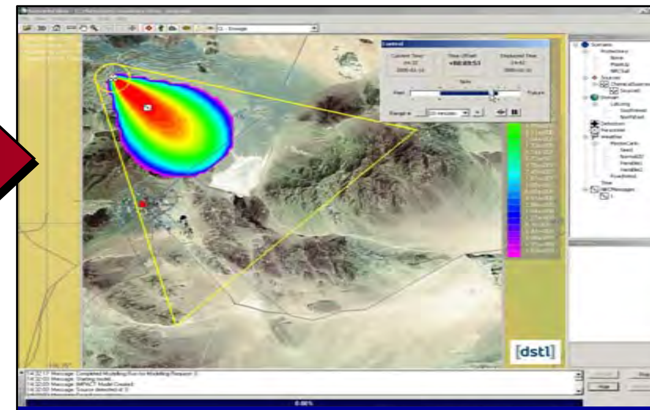
Tailorable Sensor Systems

- Broad Spectrum Detection/ Identification
- Mounted or Dismounted
- Common Interfaces
  - Service Oriented Architecture



Detector Component In Removable Cartridge

Modular Chem Bio Interface Unit



Sensor Analysis and DATA Fusion

Holster

- Componentized Sensor Framework
  - Detector is Decoupled from “Holster”
    - Deployment Platforms Often Supply “Common Services”
      - Power
      - Communications
      - Physical Connections
      - Information Assurance
- Detectors Can Operate in Multi-mode
    - Wireless or Wired
    - Via COTS Handheld Technology
    - Varying Deployment Models
- Current COTS Technology Supports Solution
    - Handheld Technology Has Advanced Enough to Support Off-The-Shelf Hardware and Software Solutions
    - Allows a Software Based Approach
    - Supports Scaleable and Upgradeable Modules

THE HOLSTER CONCEPT

WARFIGHTER EFFECTIVENESS AND SUITABILITY

Today

- ACADA
- ICAM
- DFU
- JBPDS
- BIDS
- JPS
- RADIACs

< 2 Years

- GOTS/COTS equipment
- Expanded warfighter capability

2-5 Years

* Notional concept for limited objective experiment / demonstration

- Repackaged sensors
- Modular, tailorable, plug-n-play
- Net-Centric with GPS and wireless capability
- Supports development of interface control documents and equipment specification

5-10 Years

- Miniaturization
- Auxiliary/complimentary functionality

> 10 Years

- Sensor capability integrated into warfighter ensemble

Where the C2 Systems are Headed

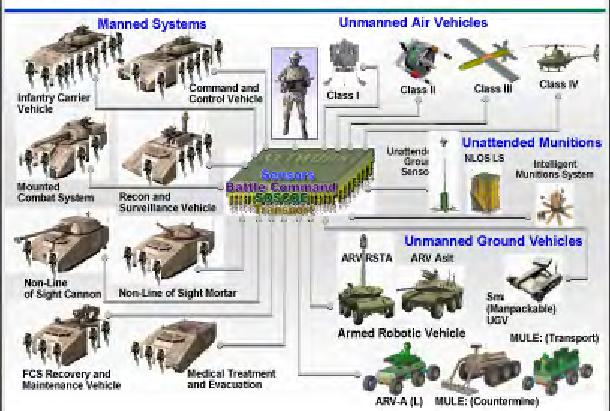
- **Navy initiative - ForceNet**
- **Army initiatives - FCS and Army Enterprise Architecture (AEA)**
- **Air Force - Constellation**

* ***There is an Initiative to Integrate the Three of These Together Towards a Next Generation, Network-centric Architecture. How Do We Play Into This From a Joint Perspective?***

JPEO Programs Will Need to Integrate to These Initiatives

Major Defense Acquisition Programs

FUTURE COMBAT SYSTEMS



CBRN REQUIREMENTS

CBR Detection
Battle Management
Integrated Early Warning
Collective Protection

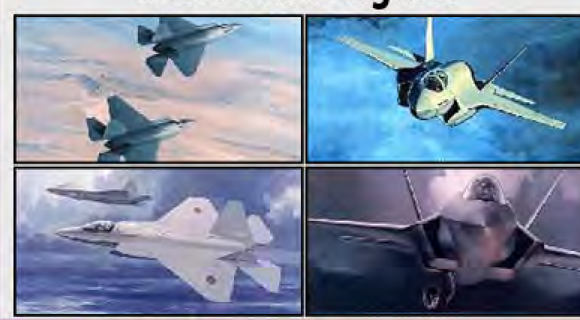
Decontamination
Individual Protection

OTHERS
Bradley, THAAD, CFPI, UAV...

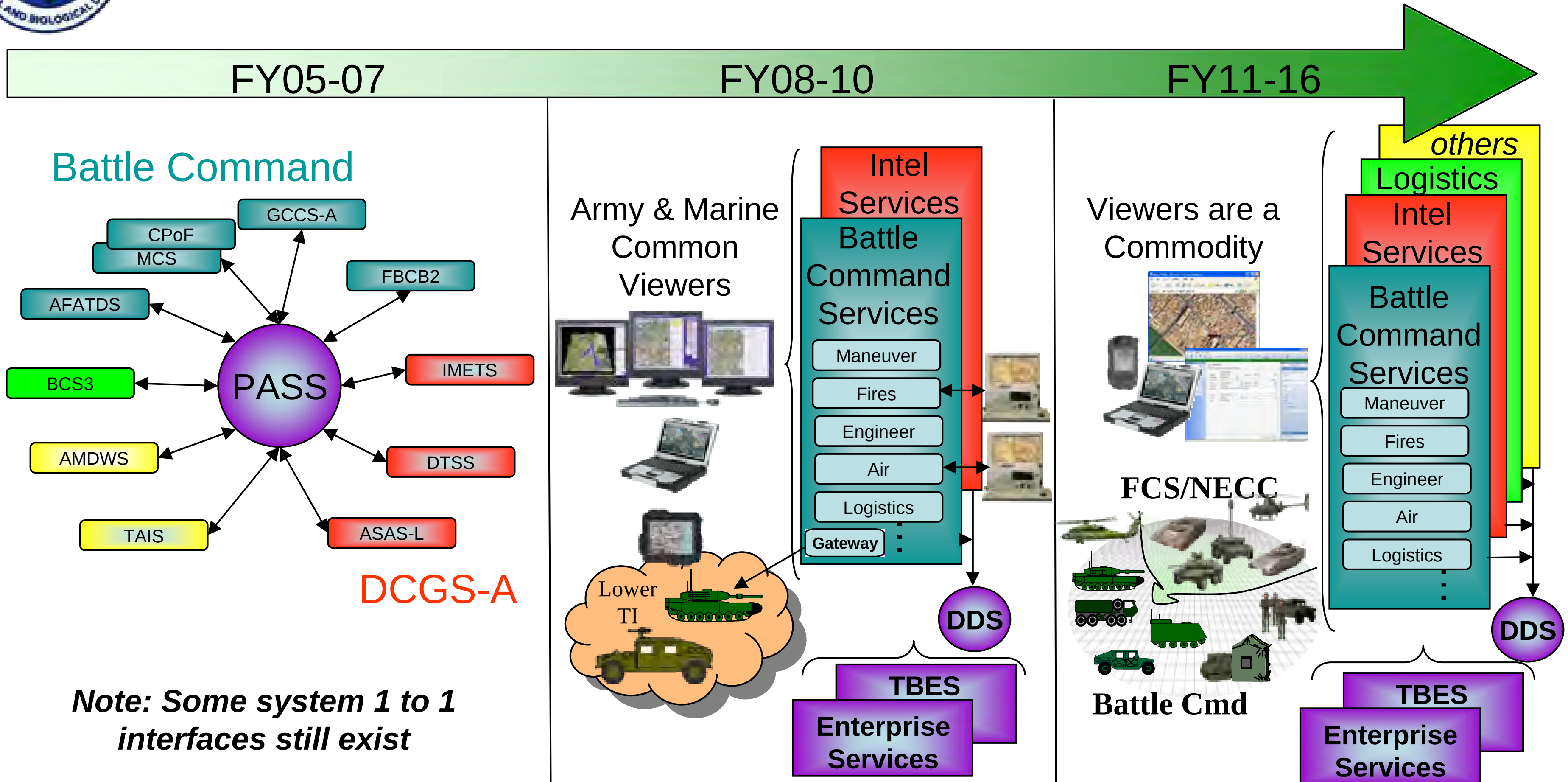
Expeditionary Fighting Vehicle

Stryker

Joint Strike Fighter



Battle Command Technical Vision



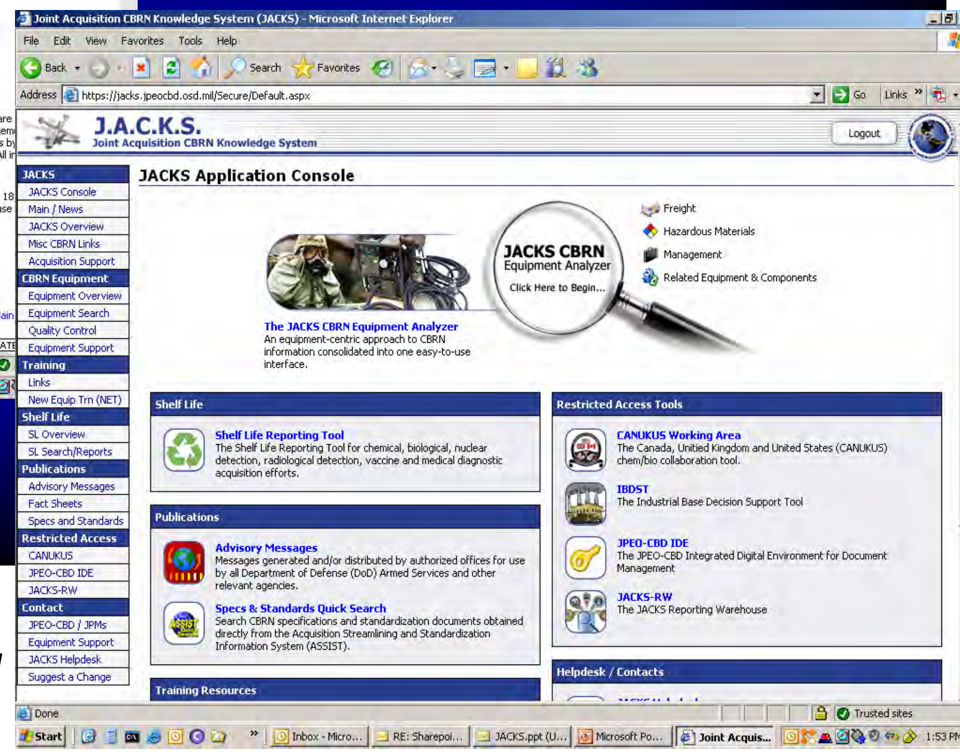
Server Centric
- Centralized service for Data exchange using standard schemas
- System of BFA independent servers and clients

Service Centric
- Common Viewers (Smart clients – CPoF, JTCW, thin client – web)
- Services Start to replace servers and Utilize common set of data
- Clients interface thru services

Network Centric
- Viewers downloaded on demand (rich thin clients)
- Domain Specific Services that utilize common set of data
- Clients interface thru services

Joint Acquisition CBRN Knowledge System

DoD Knowledge Management System

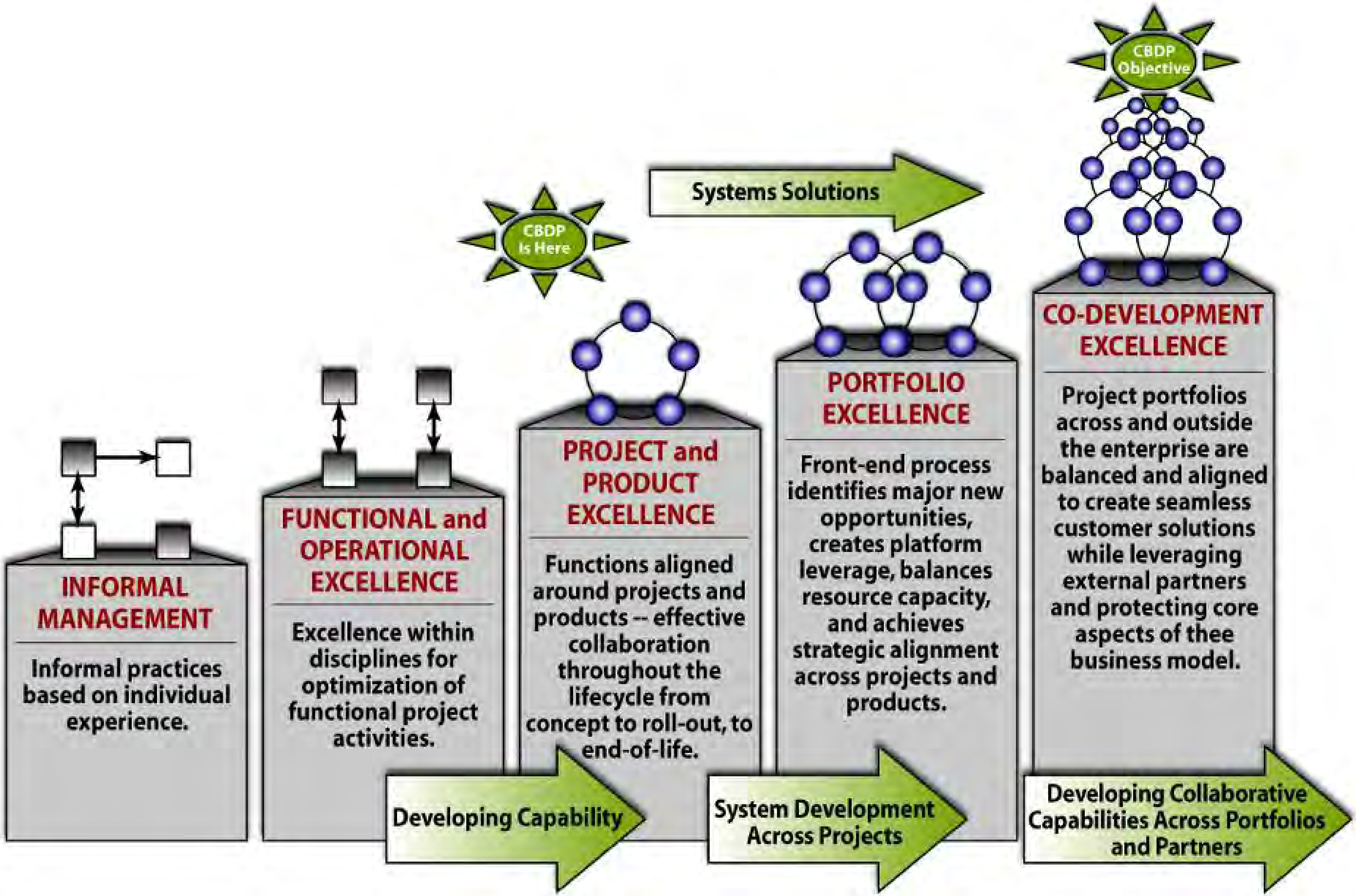


Acquisition and Support of CBRN Defense Materiel

https://jacks.jpeocbd.osd.mil

One Stop Shop for Chem Bio Defense Program Information

Focus on CB Portfolio Management



Joint Service Total Life-Cycle Management

"The PM shall be the single point of accountability for accomplishing program objectives for total life-cycle systems management, including sustainment."

– DoD Directive 5000.1, May 12, 2003, paragraph E1.29

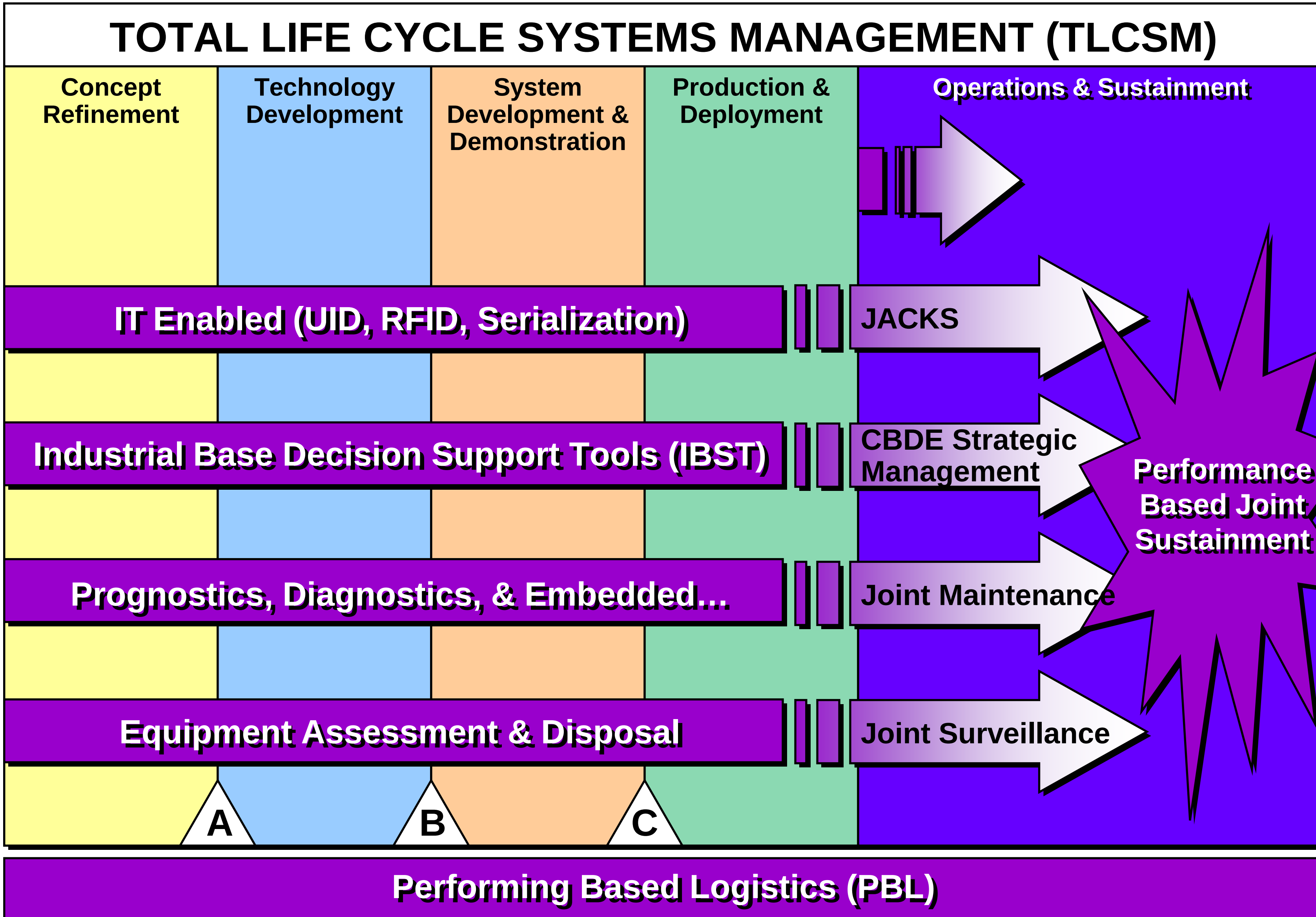
Pre-Systems Acquisition | **Systems Acquisition** | **Sustainment**

Concept Refinement | **Technology Development** | **System Development and Demonstration** | **Production and Deployment** | **Operations and Support**

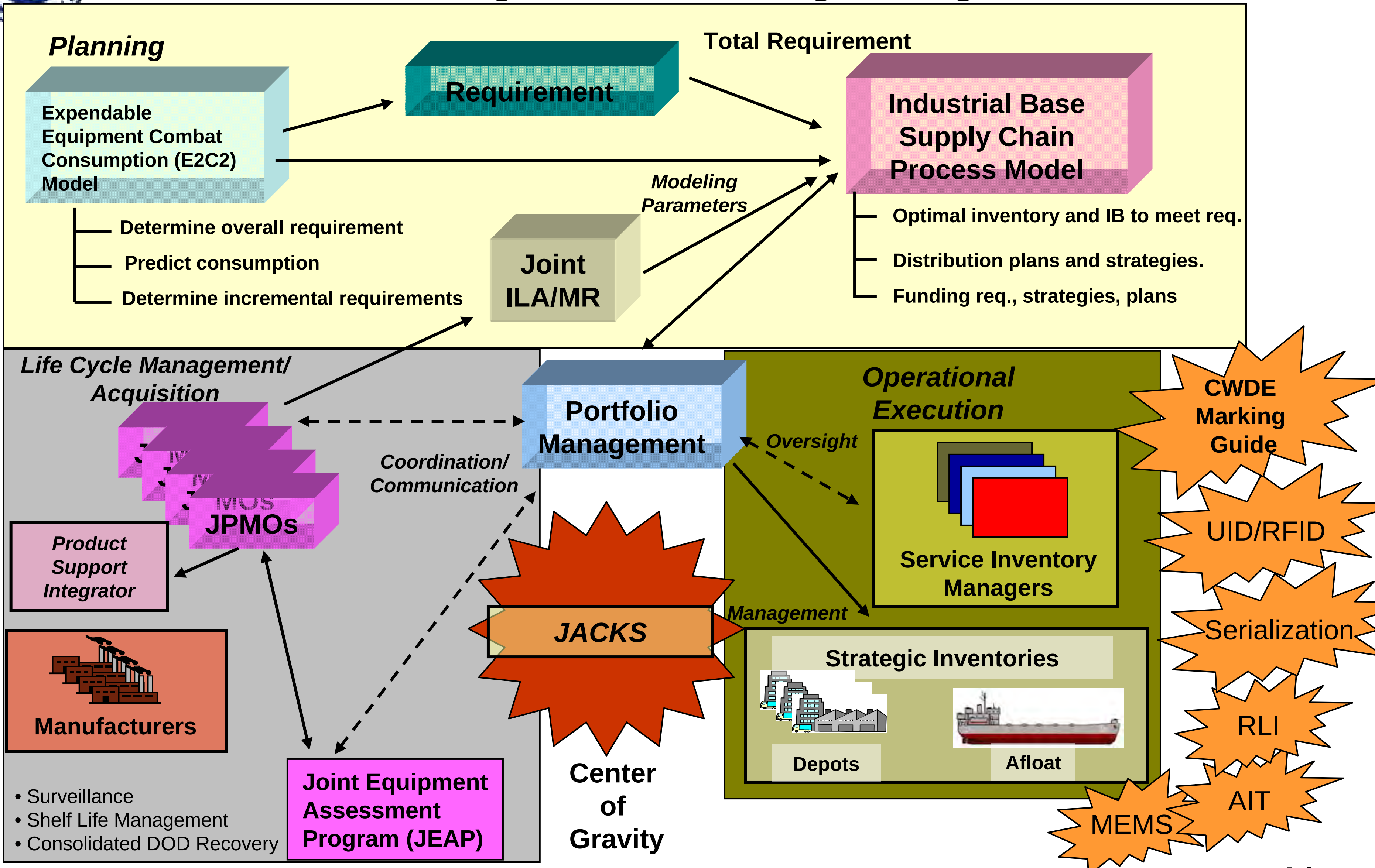
- Limited Objective Experiments
- Technology Readiness Assessments
- Monthly Program Analyst Reviews
- Total Package Fielding
- Joint Materiel Release
- Joint Logistics Advisory Council
- Technology Transition Agreements
- Monthly Acquisition Status Reports
- CBRN Joint Acquisition Knowledge System
- Joint Equipment Assessment Program
- Monthly Equipment Readiness Review
- Joint Quarterly Readiness Reviews

Performance Based Logistics – DoD Joint Logistics Board

Joint Sustainment:
The END-STATE

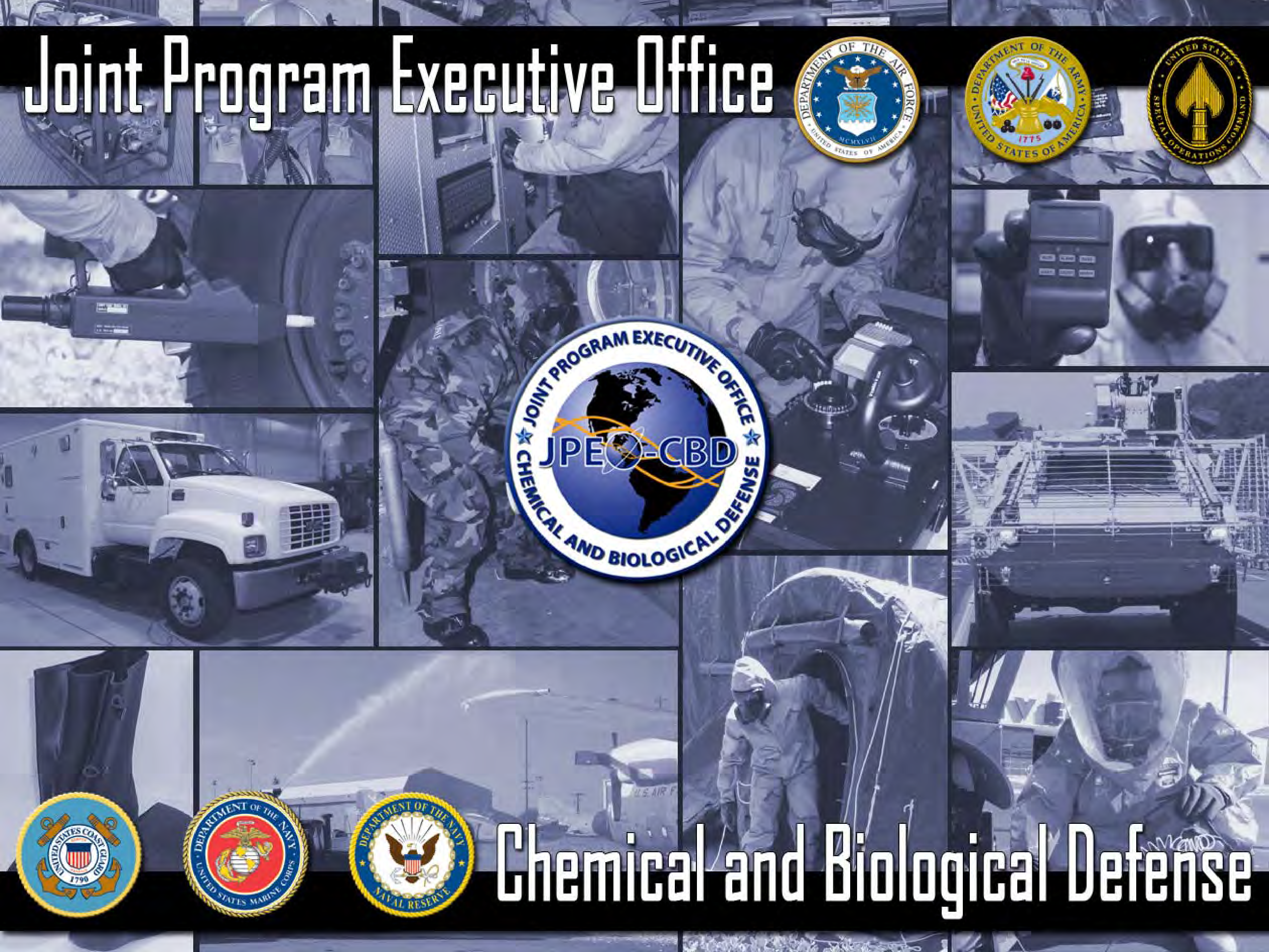


Portfolio Management: Integrating the Pieces



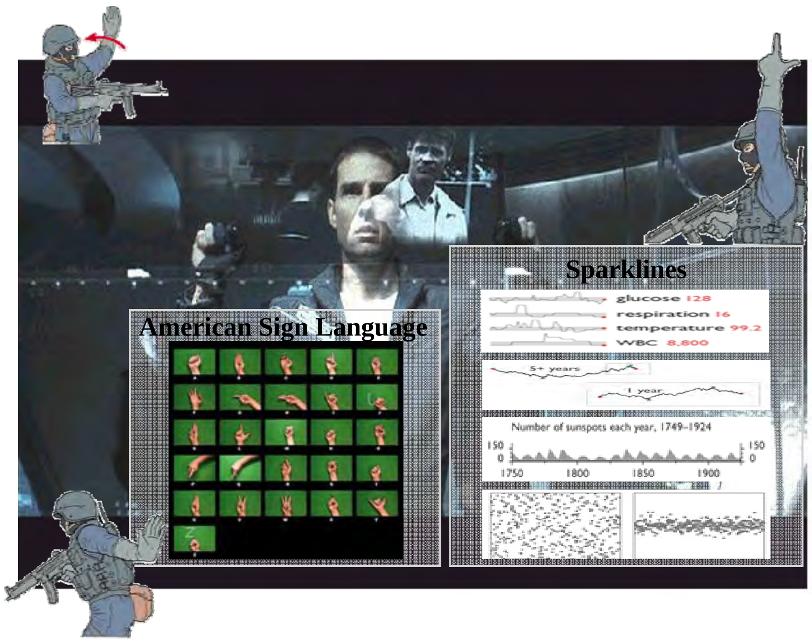
RLI – Residual Life Indication; **MEMS** – Micro-electronic mechanical systems; **AIT** – Automatic Information Technology; **UID** – Unique Identification
JACKS – Joint Acquisition Knowledge System; **JTAVRW** – Joint Total Asset Visibility Reporting Warehouse; **RFID** – Radio Frequency Identification


WE'RE AT WAR
ARE YOU DOING
ALL YOU CAN?


Joint Program Executive Office
JOINT PROGRAM EXECUTIVE OFFICE
JPEO-CBD
CHEMICAL AND BIOLOGICAL DEFENSE
Chemical and Biological Defense

Next Generation Tactical Situation Assessment Technologies (TSAT)

"Iconic Chat Data Glove"



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Agenda

- Objective: Chat in Situation Assessment (SA):
  - Today
  - Tomorrow's Vision
- Technical Approach w/emphasis on FY07 Goal
  - **Linguistic Research and Analysis** focusing on predicting situation assessment *content*
  - **Visual/Icon-based Language** of Situation Assessment
  - **Technology of Inscription** (Keyboard-Independent Data Entry Technology for hostile/extreme environments)

Today’s Chatroom as Context Sharing “Technology”

- ***Chat is the Primary*** and often ***singular*** means of tactical communication for situation updates on intermittent/discontinuous networks, superseding radio communications
- **Strikegroup (ship) CONOPS**: Establish 500-800 chatrooms, 2-4000 users in each “channel,” based on functional roles; establish at beginning of mission, continuing for months to years
- **Joint CONOPS**: Establish hundreds of chatrooms in theater of operations with joint service participation, based on mission objectives; allows joint access to service specific chatrooms to maintain non-intrusive situation awareness of service-specific activities
- **Chat Functions**:
  - Supports real-time targeting;
  - Supports edge users (on low/intermittent b/w)
  - Immediate COP context updates
  - General information sharing updates on regular basis (across months) to establish ops-tempo/battle rhythm management
  - Supports Cross-Domain operations

What it looks like today: 1980→2006

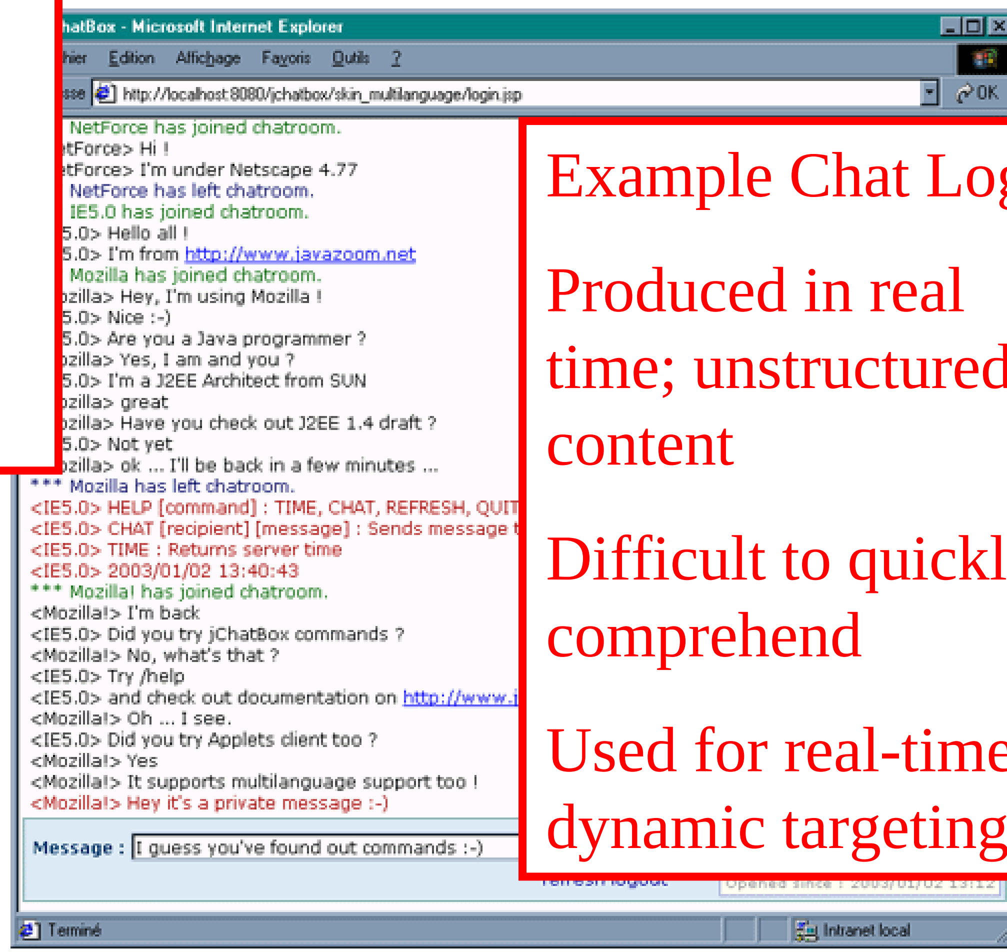
R xxxxxxZ OCT
FM COMCARS
TO USJFCOM
USPACOM
ALLIED COMM
AC2C4ISR LA
DISA WASHIN
SPAWAR SYS
NAVAL POST
USS ENTERPR
USS ANZIO
INFO COMMANDER NAVAL NETWORK WARFARE COMMAND
BT
MSGID/GENADMIN/COMCARSTKGRU TWELVE/-/OCT//
SUBJ/WELL DONE//
RMKS/1. I WISH TO SEND NOTE OF PERSONAL THANKS FOR YOUR SUPPORT OF OUR JOINT/COALITION OPEN STANDARDS TACTICAL CHAT DEMONSTRATION ON 19 OCT 05. YOUR ORGANIZATIONS PROVIDED EXCEPTIONAL SUPPORT IN TERMS OF ENGINEERING, EQUIPMENT TO HOST THE TEST, AND PERSONNEL TO PARTICPATE AND PROVIDE FEEDBACK. THE TEST WENT EXCEEDINGLY WELL AND WOULD NOT HAVE BEEN POSSIBLE WITHOUT YOUR ASSISTANCE AND DEDICATION. SPECIAL APPRECIATION GOES TO:

DMS (and Email):

Produced Time-late

Difficult to read

Not used for real-time ops, but as formality



Example Chat Log:

Produced in real time; unstructured content

Difficult to quickly comprehend

Used for real-time dynamic targeting

S&T Challenge

- **Objective**: Enhance *rapid* situation assessment updates among teams of warfighters in a hostile environment through language improvement and novel, wearable computing devices.
- Today's Chat, should, in 10 years:
  - Must not be solely text-driven (too slow; too ambiguous, very unstructured)→combined, efficient icon + text
  - I-18-n=Internationalization capable
  - Must be able to accommodate edge (*tactical*) users
    - Capable at very low b/w, high jitter environment
    - Chemical-Biological Warfighters in MOPP gear
    - Special Operations in Hostile Settings: oil spills, fire, tsunamis, oxygen-deprived environments
    - Very-Edge Users: minesweepers, submarines, and astronauts
  - Must be able to integrate with geographic land-based terrain maps and COPs, *AND* non-geographic *computer-based* "terrain" (global network ops-network topology)

Technical Approach

- **Linguistic Research & Analysis**
  - Improve the ability to derive ***the content* of current chat** messages, by defining candidate linguistic "themes" of warfighter language, for transition to an augmented icon-based language, to improve efficiency of knowledge sharing
- **Visual/Icon-based Language of Situation Assessment**
  - Develop a **icon/symbol-based language** to augment text, used to more quickly communicate complex relationships and *evolution* of relationships of objects of interest in geographic and non-geographic environments; a true combat "*leet speak*"
- **Technology of Inscription**
  - Prototype a revolutionary *keyboard-independent* **technology of inscription** for this new language**,** for use in a Net-Centric Warfare environment

Linguistic Research & Analysis

- Fleet usage of chat is widespread, but current tools and management of chat databases are vastly inadequate for information retrieval
  - ASW
  - Air Force
  - Battlewatch centers
- Accurate portrayal of the military chat domain is essential for any future improvements to chat clients, GUIs, or methods of use.
- Identifying topic trends present in all military chat domains can help to define the problem space
- Statistical analysis of chat--its structure, topical organization, and user trends--must first be applied

Linguistic Research & Analysis

Computer Mediated Discourse (CMD)

- A field of study that focuses primarily on unstructured textual analysis
- Modes of communication include chatrooms, instant messaging, emails, wikis, and blogs

Text Data Mining

- A data mining application that reveals new information from text collections
- Computational Linguistics employs text data mining to statistically analyze corpora in order to discover useful patterns or trends

Linguistic Research & Analysis

Methodology

- A corpus, or collection of texts, must first be preprocessed to remove information-poor terms
  - Determiners
  - Conjunctions
  - Modifiers
  - Tokenization
  - Lemmatization
- Once a corpus has been reduced to its most information-heavy state, statistical analyses can be applied
  - Word sense disambiguation
  - Text categorization
  - Clustering

Visual & Icon-based Language

Chat is currently primarily textual, however…
- Symbolic and visual information is prevalent
- Visual information is often embedded directly within chat
    - emoticons: **:)**
    - acronyms: **lol** - **5,689 documented acronyms** in use by DoD (Joint Publication 1-02)
    - wordplay (l337 speak): **t8k m3 700 j00r 13373r**
    - color: speaker identification, **emphasis**, differentiation
    - hyperlinks / URIs
    - embedded icons & images:
    - file & object attachments:
- These are natural and inevitable augmentations of textual-based communication
- Convey information in a **simple**, **compact**, and **efficient** manner
- Neither chat nor its visual content is disciplined:
    - loose associations
    - language misuse
    - ambiguous acronyms
    - no formal chat iconography or integration with existing standards for symbols (MIL STD 2525b, NATO Military Symbols) or acronyms (Joint Publication 1-02)
    - difficult to use entry and retrieval mechanisms

These problems result in a loss of shared context, information loss, and communication errors

Visual & Icon-based Language

We want chat users to utilize visual language and visual representations of knowledge.

Why?

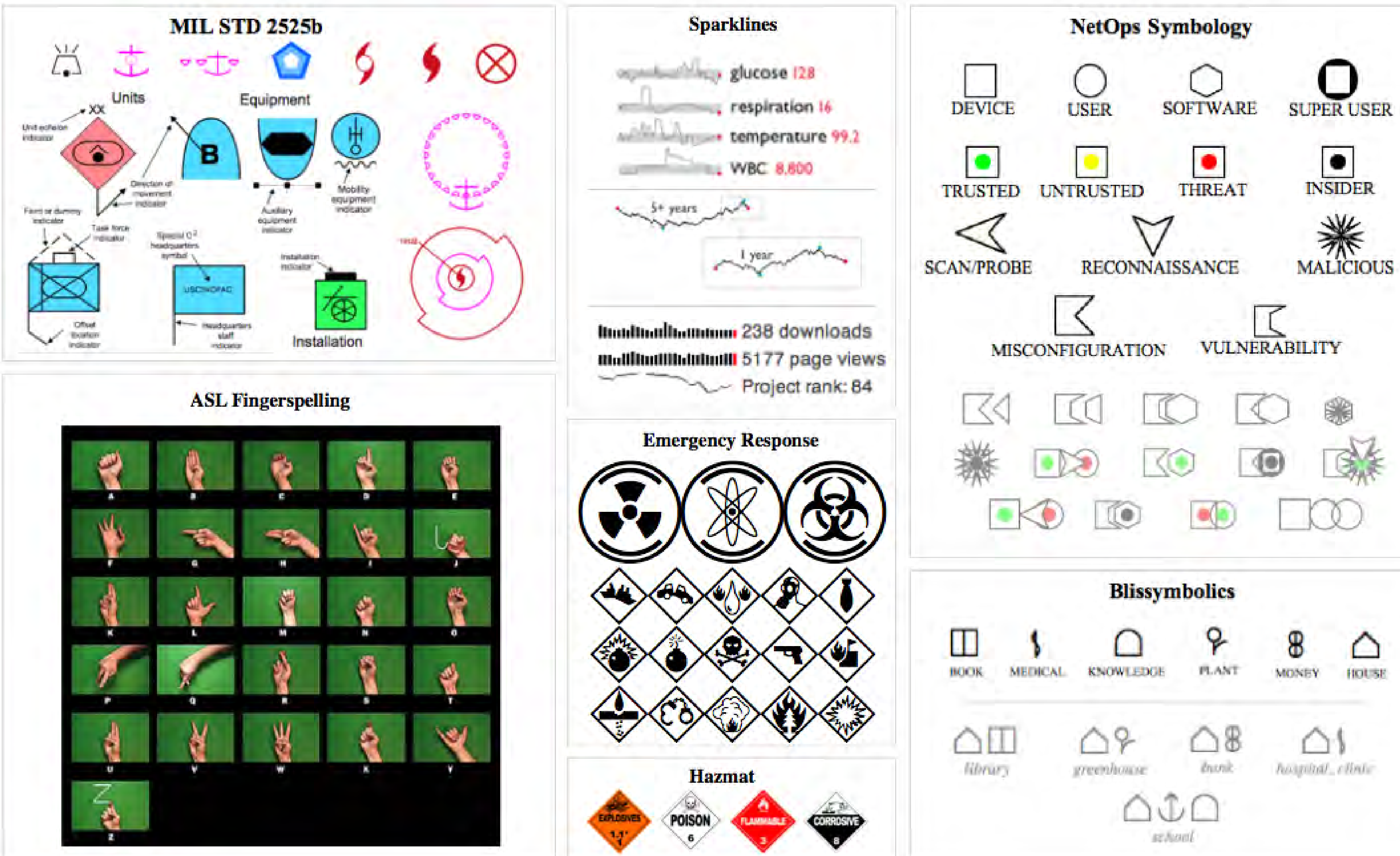
- Increase information carrying capacity
- Enhance expressiveness of the chat medium
- Eliminate ambiguity when using a formal iconography and shared context
- Embrace the concept of **shared context**
- Enable a radical transformation of the communications medium
- Provide a natural bridge between gesture and text communication

"…gesture supplies a visual, iconic component that can provide extra information or circumvent prolonged explanation….Moreover, people naturally resort to manual gestures when trying to communicate with people who speak a different language."

Dr. Michael C. Corballis, 1999
"The Gestural Origins of Language"

How can we best augment, disambiguate, and improve textual content using visual representations of language, objects, and information?

Visual & Icon-based Language



Technology of Inscription

Development of a keyboard-independent language-entry device

- Initial development of a wireless glove capable of digitizing movement and position of user’s fingers, hands and arms
- Glove can operate as a keyboard/input replacement where a standard keyboard would not be possible (hostile environment/chemical fires/biological threat) or is inconvenient (in space/underwater)
- Capable of recognizing static and dynamic gestures

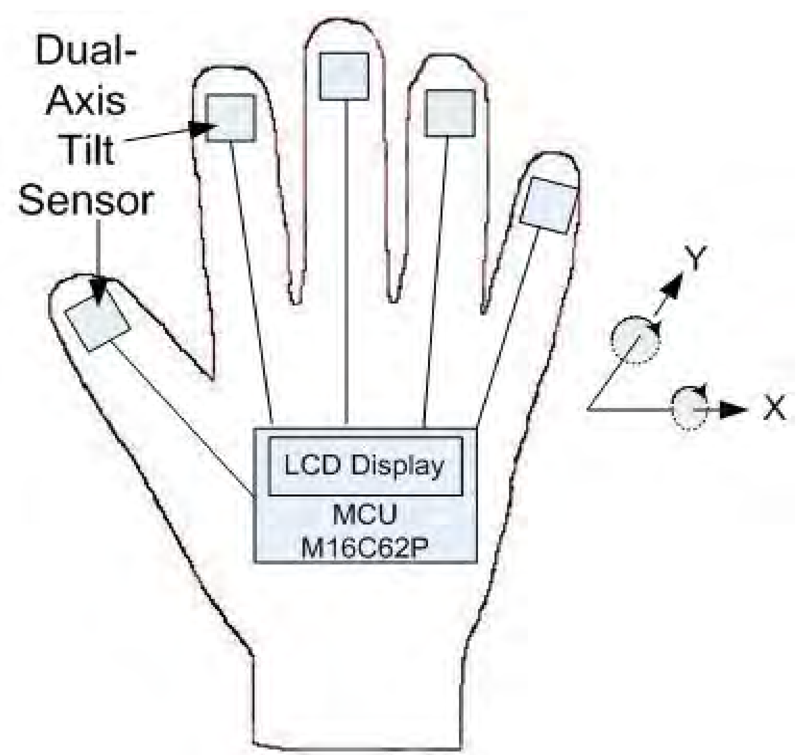
Technology of Inscription Gestures in Hostile Environments

- Noisy environment: speech not viable or difficult to discern (>5 “talking;” chemical fires, liftoff; outerspace; underwater)
- Covert/silent environment: need to communicate without alerting enemy
- Precise communication: gestures can be an efficient means of communication, coupled with persistent storage

Static Gestures

Dynamic Gestures

Technology of Inscription Data Glove Prototype



Layout Sensors

A complete glove system

FY07 Goals

Linguistic Research and Analysis

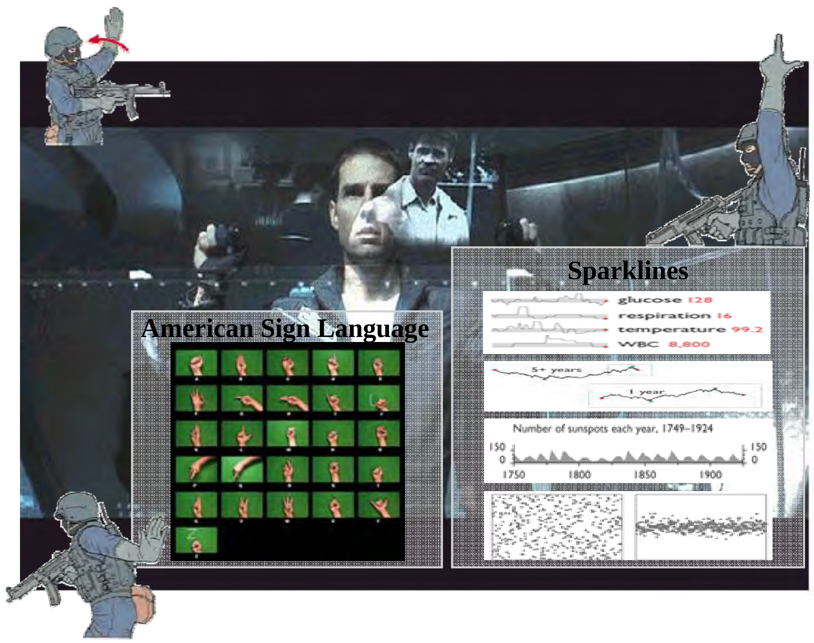
- Metrics identification and testing
- Statistical analysis of chatroom topical content, user trends/themes
- Initial prototype in place for chat user database or topic threading detection

Visual and Icon-Based Language

- Research state-of-the-art visual language techniques which can be applied to Situation Assessment chat communication
  - Icons & Acronyms: MIL STD 2525b, JP 2-01
  - Constructed languages: Blissymbolics, Phonetic Picture-writing
  - Domain specific languages: ChemBio, ASW, NASA, Special Forces, Global NetOps
- Identify innovative presentation mechanisms which can be used
- Application specific visual communication: Gesture, ASL
- Determine metrics for ease of use, efficiency, and ambiguity resolution. Does information capacity (knowledge) increase with less keystrokes?

Technology of Inscription

- Reconfigure sign language glove for wireless connectivity
- 1st Generation Programmable interface
- Work with G-speak/MIT/UCIrvine/UCSD/NASA on novel interface methods


Sparklines
glucose 128
respiration 16
temperature 99.2
WBC 8,800
5+ years
1 year
Number of sunspots each year, 1749–1924
150
0
1750
1800
1850
1900
150
0
American Sign Language

Questions?

Linguistic Research & Analysis References

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Visual & Icon-based Language References

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SPAWAR
Systems Center
San Diego

G-Speak Gestural Technology

g-speak is the first commercially oriented gesture recognition company, with solutions already in development in the defense and aerospace sectors. g-speak inventor and company founder John Underkoffler consulted on “Minority Report” to develop the gesture language used by characters to call up and sift through video material in that futuristic film.

www.**g-speak.com** (for CBS video) or contact Thomas Wiley at (323) 244-8366.

http://www.g-speak.com/

Air Force Weather Agency

Integrity - Service - Excellence

Supporting Transport & Dispersion Modeling with Stochastic Weather

Maj (PhD) Tony Eckel
Ensemble Projects Manager
Air Force Weather Agency

Mr. Steven A. Rugg
Chief, Fine Scale Models Team
Air Force Weather Agency

U.S. AIR FORCE

Overview

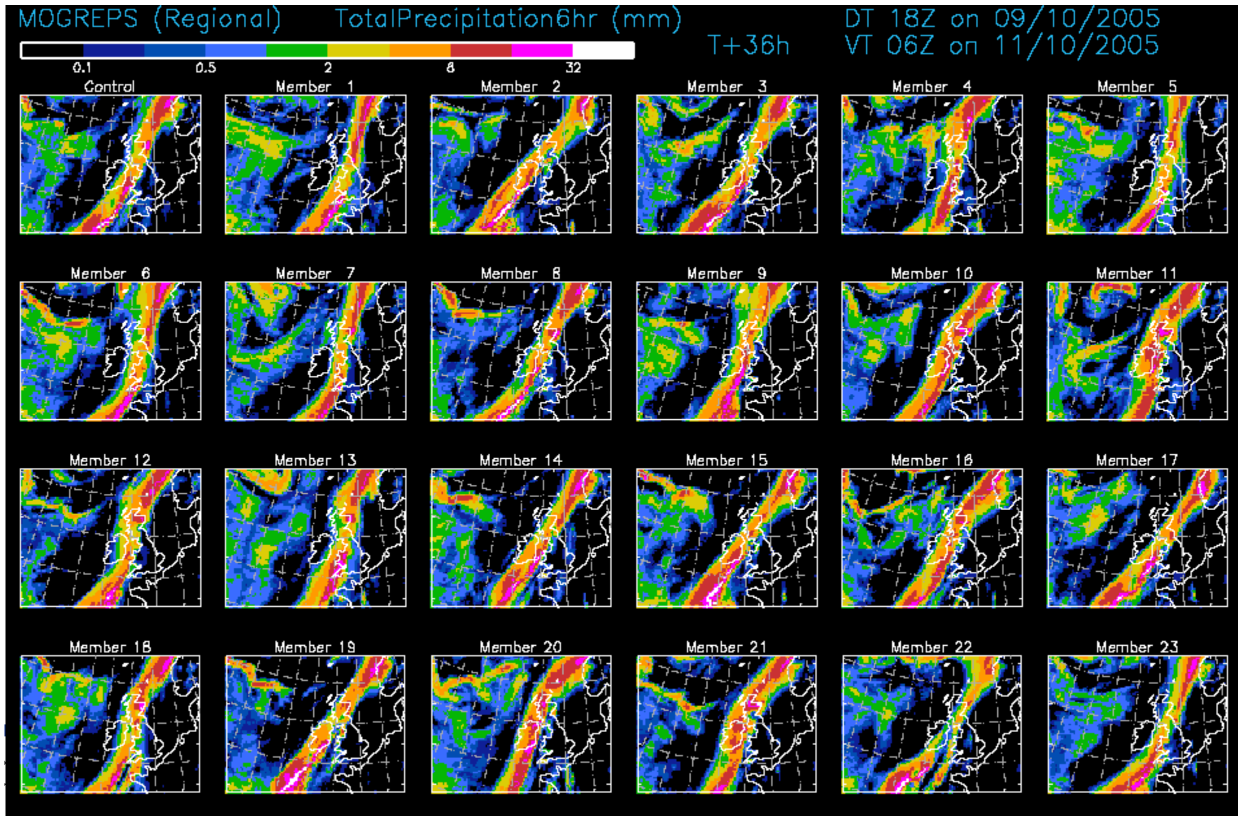
- Background
  - Definitions
  - Why ensembles?
- Theory
  - Deterministic vs. Stochastic Weather
  - Limitations
- Development
  - Joint Ensemble Forecast System (JEFS)
  - Ensemble Prediction System (EPS)
- Application & Education
  - Forecast Process
  - Warfighter Decision Making

Background

Definitions

- **<u>Stochastic Weather</u>:** Description of the spectrum of possibilities for the state of the atmosphere
- **<u>Ensemble Forecast</u>:** (General) Multiple, unique forecasts for the same event
  - (Rigorous) Multiple, unique numerical weather prediction runs (*members*) for same valid period, capturing all sources of uncertainty

<u>Sample Rigorous Ensemble</u>
UK Met Office Global and Regional Ensemble Prediction System (MOGREPS)
- 25km Grid
- 36h Forecasts
- 24 Members
- Varied Analyses (EtKF)
- Varied Model (Stoch. Phys.)



Ensemble Startup

Operational Center / Current Ensemble ...as of Dec 2007

1992 **The National Center for Environmental Prediction (NCEP)**
- **Global**: 30 members, 4/day, T126/L28 (~110 km), 15-day forecast
- **Limited Area**: 21 members, 32 km, 60-hour forecast

1992 **The European Centre for Medium-Range Weather Forecasts (ECMWF)**
- **Global**: 51 members, 2/day, T399/L40 (~ 35 km), 14-day forecast

1995 **Fleet Numerical Meteorology and Oceanography Center (FNMOC)**
- **Global**: 18 members, 1/day, T119/L24 (~120 km), 10-day forecast

1996 **Canadian Meteorological Center (CMC)**
- **Global**: 16 members, 2/day, 10-day forecast

1996 **China Meteorological Agency (CMA)**
- **Global**: 21 members, 1/day, T213/L31 (~ 65 km), 10-day forecast

2000 **Australian Bureau of Meteorology (BoM)**
- **Global**: 33 members, 2/day, T119/L19 (~ 120 km), 10-day forecast

2001 **Japan Meteorological Agency (JMA)**
- **Global**: 51 members , 1/day, T159/L40 (~ 90 km), 9-day forecast

2001 **Korean Meteorological Administration (KMA)**
- **Global**: 32 members, 1/day, T213/L40 (~ 65 km), 8-day forecast

2007 **United Kingdom Meteorology Office (UKMet)**
- **Global**: 24 members, N114/L38 (~120 km), 72-hour forecast
- **Limited Area**: 24 members, 25 km, 36-hour forecast

Why Ensembles for USAF?

- **Ensemble Forecasting (EF) provides objective, high quality *stochastic weather* to enable optimal decision making for:**
  - **<u>Effectiveness</u>: Maximize Mission Capability**
  - **<u>Efficiency</u>: Conserve Resources**

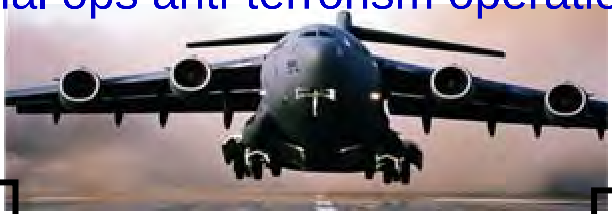
- ***<u>Letter to Airmen: Air Force Smart Operations 21</u>*** **(SECAF, Mar06)**
  "…a dedicated effort to maximize value and minimize waste in our operations."

  "AFSO 21 signifies a shift in our thinking…innovative ways to use our material and personnel more effectively."

- **<u>AF Policy Directive 90-9</u> – *"All Air Force personnel will apply ORM principles, concepts, and techniques to assess the risks associated with their daily mission and duty-related activities."***

Deterministic Wx vs. Stochastic Wx Application

Mission: C17 needed to deliver urgent equipment and supplies from CONUS to Pakistan for covert, special ops anti-terrorism operation. Air Refueling required.



Current Scenario
(deterministic wx support)

Wx fcst for primary AR track:
Sky: CLR
Vis: 7+ miles
Turb: MDT-SVR FL180-300
Icing: Neg
TSTMS: ISOLD

Action: C17 plans to use alternate refueling track. Refueling successful.

Result: Mission accomplished

Cost: Supplemental KC10 costs due to alternate track
- flight time: 2.5 hr (crew stress)
- fuel: 42,000 lbs ($27K)

Future Scenario
(stochastic wx support)

Wx fcst for primary AR track:
Sky: CLR
Vis: 7+ miles
Turb: 25% chance > MDT
Icing: Neg
TSTMS: 15% chance

Action: C17 plans to use primary track (accept known risk). Refueling successful.

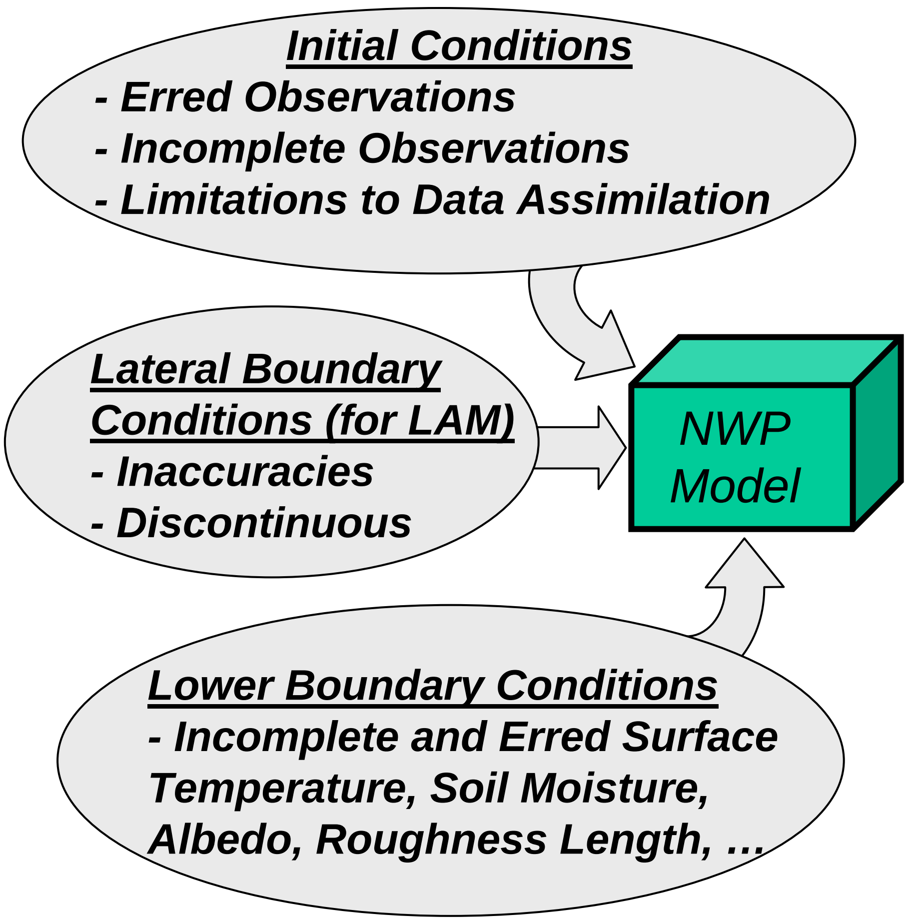
Result: Mission accomplished

Cost: Maximized efficiency and minimized cost through enabling of ORM

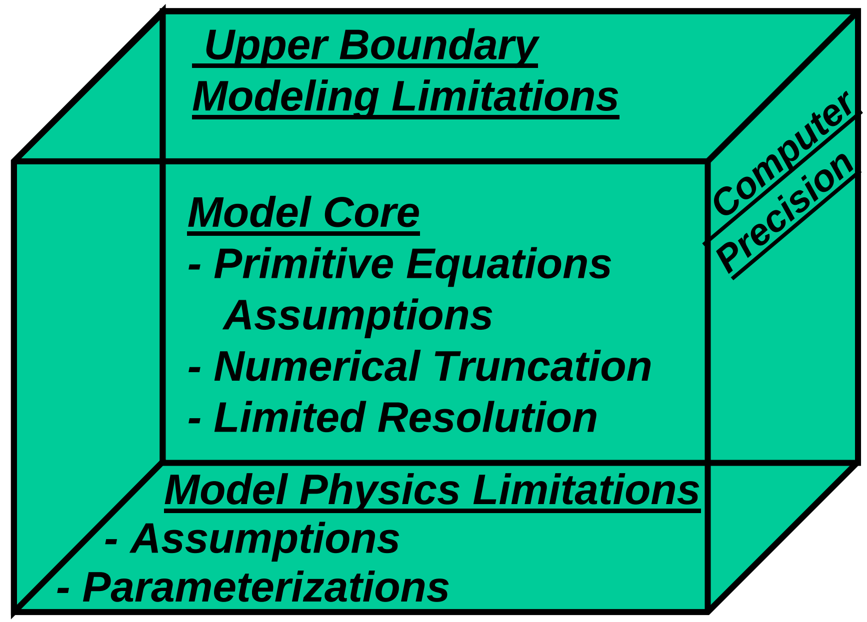
Theory

Causes of NWP Uncertainty

Source Data



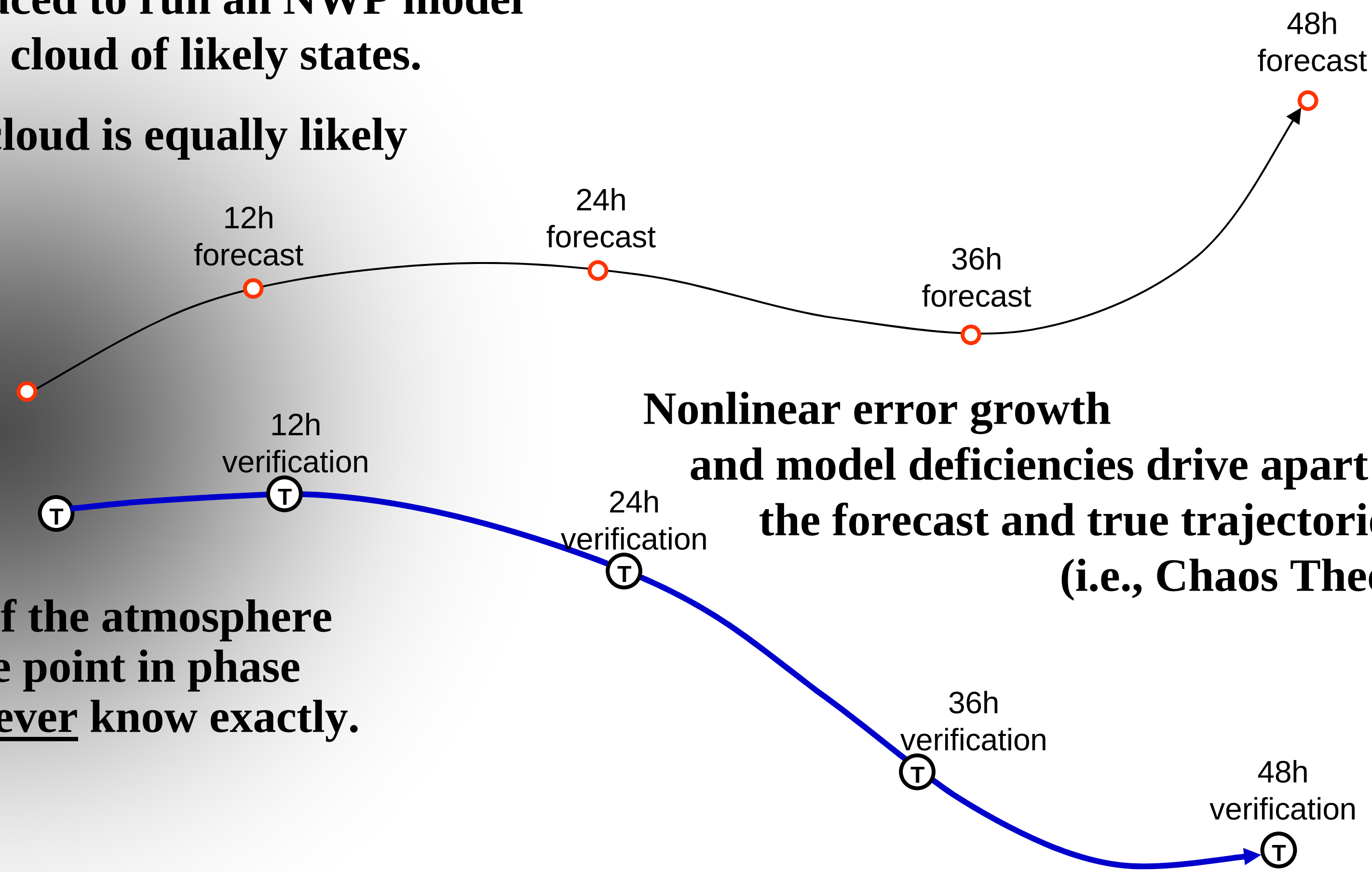
Computational



Deterministic Forecasting Limitations

An analysis produced to run an NWP model is somewhere in a cloud of likely states.

Any point in the cloud is equally likely to be the truth.



Nonlinear error growth and model deficiencies drive apart the forecast and true trajectories (i.e., Chaos Theory)

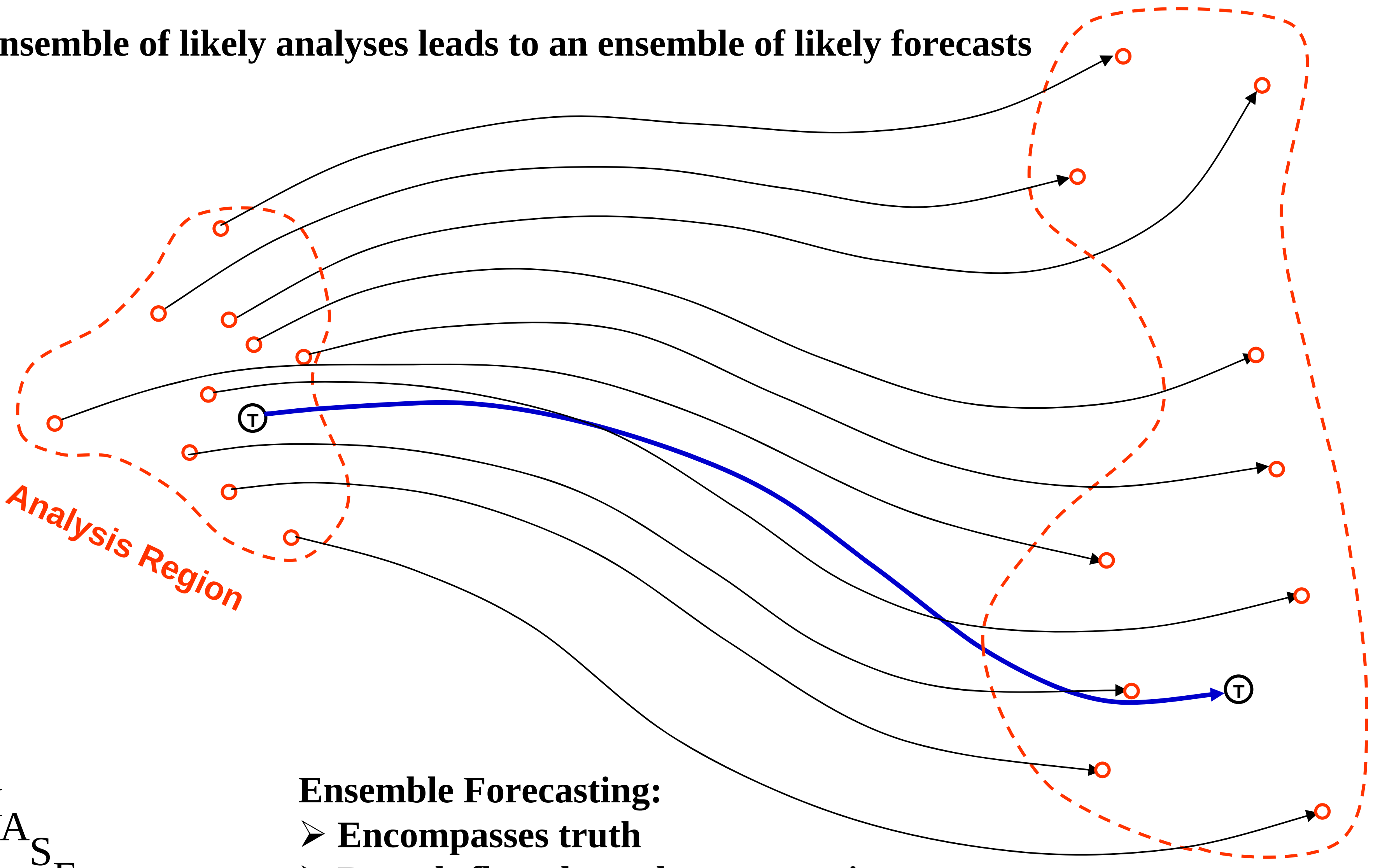
The true state of the atmosphere exists as a single point in phase space that we <u>never</u> know exactly.

PHASE SPACE

A point in phase space completely describes an instantaneous state of the atmosphere. (pres, temp, etc. at all points at one time.)

Ensemble Forecasting, a Stochastic Approach

An ensemble of likely analyses leads to an ensemble of likely forecasts



P H A S E
S P A C E

Ensemble Forecasting:

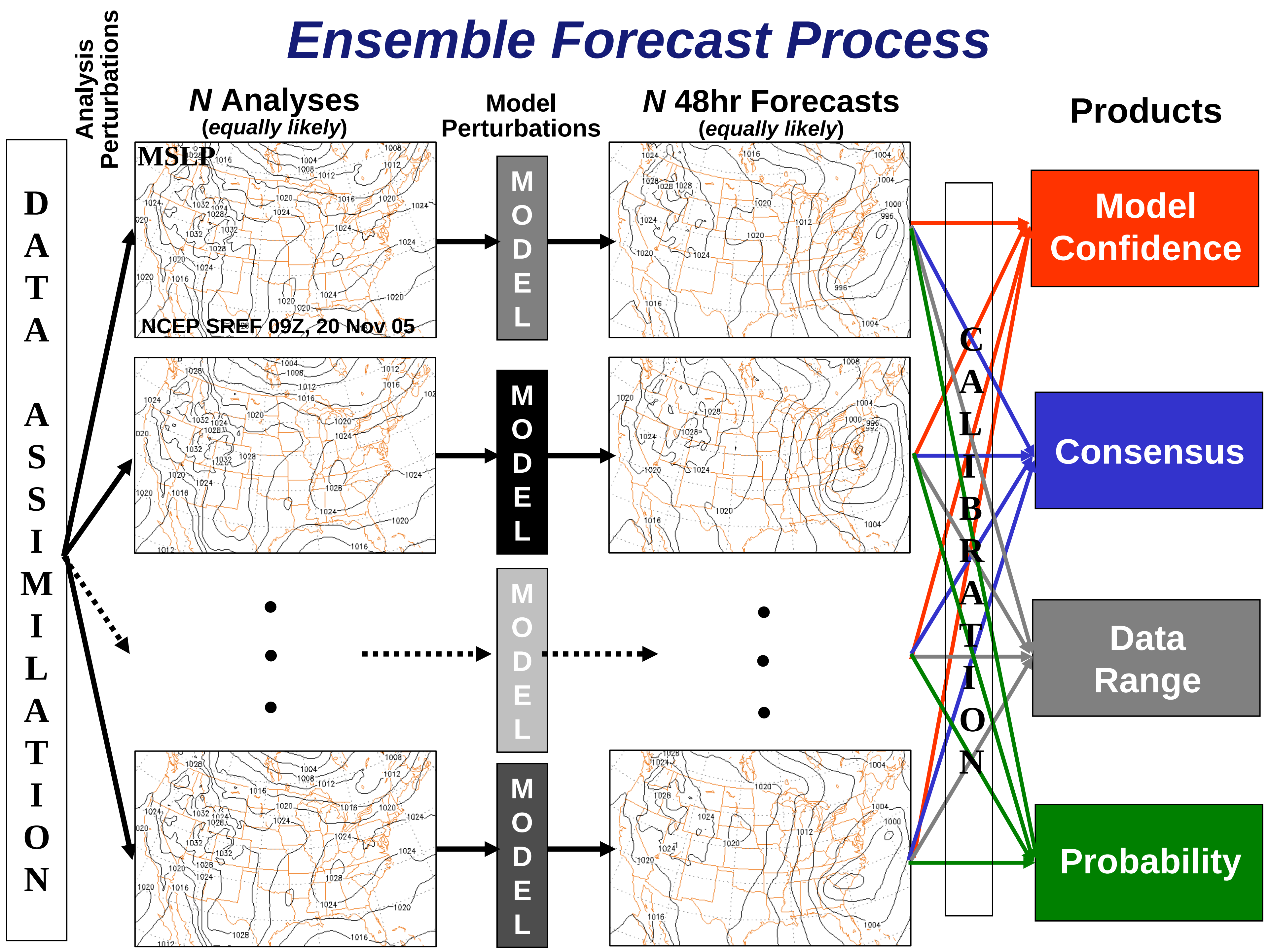
- **Encompasses truth**
- **Reveals flow-dependent uncertainty**
- **Yields objective stochastic forecast**

Limitations

- Stochastic Weather is <u>not</u> a panacea
  - Only required when *uncertainty* exceeds operational *sensitivity*
  - Ensembles <u>quantify</u> uncertainty…doesn't ELIMINATE it !
  - Operator still susceptible to unfavorable outcomes
  - KEY: Minimize impact from unfavorable outcomes

- Short Falls of raw ensemble (*or deterministic*) output
  - Limited # of members
  - Model bias
  - Insufficient accounting for initial and model error
  - Insufficient model resolution
  - ANSWER: Calibrate to adjust raw output

Development



Ensemble Forecast Process
Analysis Perturbations
N Analyses
(equally likely)
Model Perturbations
N 48hr Forecasts
(equally likely)
Products
DATA ASSIMILATION
MSLP
NCEP SREF 09Z, 20 Nov 05
MODEL
MODEL
MODEL
MODEL
CALIBRATION
Model Confidence
Consensus
Data Range
Probability

The
Joint Ensemble Forecast System
JEFS

GOAL: Prove the value, utility, and operational feasibility of EF to DoD operations.

FOCUS: How to best exploit EF output within forecasting and decision processes.

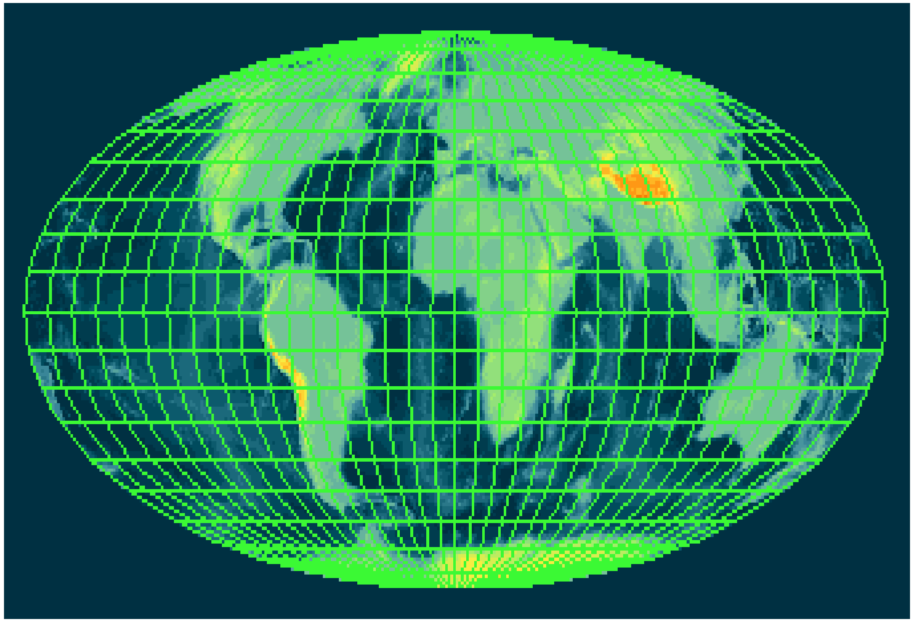
Department of Atmospheric Sciences
University of Washington

NCAR

Joint Global Ensemble (JGE)

U.S. AIR FORCE

- *Description*: Combination of current GFS and NOGAPS global, medium-range ensemble data. Possible expansion to include ensembles from CMC, UKMET, JMA, etc.
- *Initial Conditions*: Ensemble Transform (GFS) and Breeding Modes[1] (NOGAPS)
- *Model Variations/Perturbations*: Two unique models, but no model perturbations
- *Model Window*: Global
- *Grid Spacing*: 1.0°× 1.0° (~80 km)
- *Number of Members*: 46 at 00Z
  30 at 12Z
- *Forecast Length/Interval*: 10 days/6 hours
- *Timing*
  - Cycle Times: 00Z and 12Z
  - Products by: 07Z and 19Z



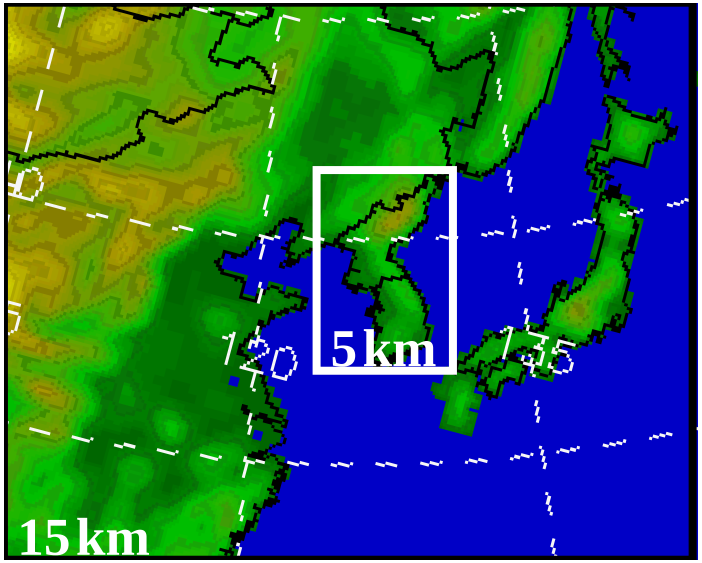
[1] Toth, Zoltan, and Eugenia Kalnay, 1997: Ensemble Forecasting at NCEP and the Breeding Method. *Monthly Weather Review*: Vol. 125, No. 12, pp. 3297–3319.

Joint Mesoscale Ensemble (JME)

U.S. AIR FORCE

- *Description*: Multiple high resolution, mesoscale model runs at FNMOC and AFWA
- *Initial Conditions*: Ensemble Transform Filter[2] run on short-range (6-h), mesoscale data assimilation cycle driven by GFS and NOGAPS ensemble members
- *Model variations/perturbations*:
  - Multimodel: WRF-ARW, COAMPS
  - Varied-model: various configurations of physics packages
  - Perturbed-model: perturbed surface boundary conditions (e.g., SST)
- *Model Window*: East Asia (COPC directive, Apr '04)
- *Grid Spacing*: 15 km for baseline JME (fall '06)
  5 km nest (in summer '07)
- *Number of Members*: 20-30 (½ AFWA, ½ FNMOC)
- *Forecast Length/Interval*: 60 hours/3 hours
- *Timing*
  - Cycle Times: 06Z and 18Z
  - Products by: 11Z and 23Z

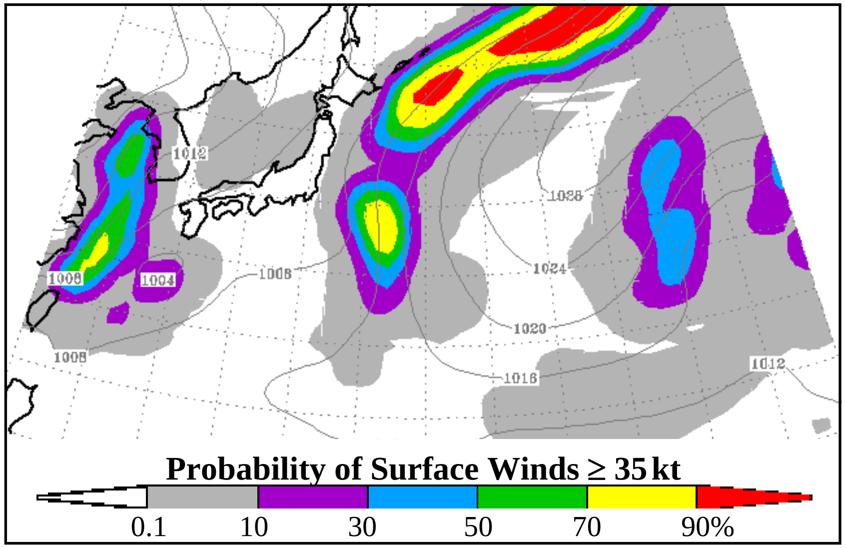
~5 h production /cycle



[2] Wang, Xuguang, and Craig H. Bishop, 2003: A Comparison of Breeding and Ensemble Transform Kalman Filter Ensemble Forecast Schemes. *Journal of the Atmospheric Sciences*: Vol. 60, No. 9, pp. 1140–1158.

Need Tools to Bridge the Gap

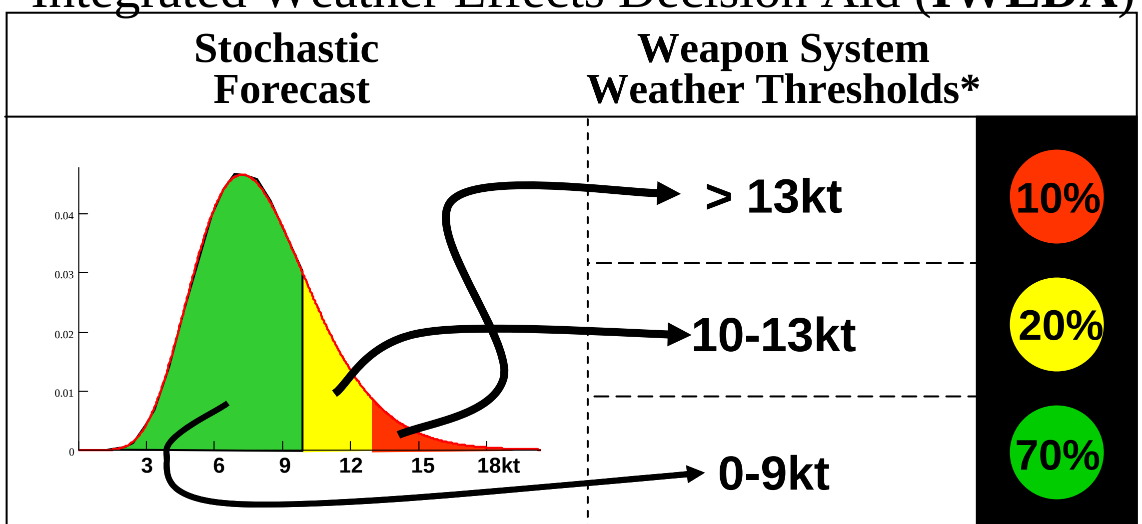
Characterize the Environment
(Stochastic Forecast)



?

Integrate and Exploit
(Binary Decisions/Actions)

Integrated Weather Effects Decision Aid (**IWEDA**)



*AFI 13-217

Application
&
Education

Weather Risk Analysis and Portrayal (WRAP)

Given uncertain weather, lower acceptable risk means less certainty in the desired outcome.

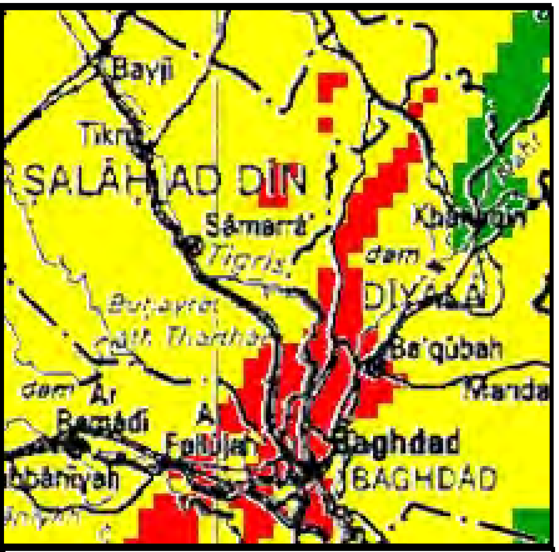
Stochastic Weather Data

Warfighter Risk Tolerance

IWEDA Rules

WRAP

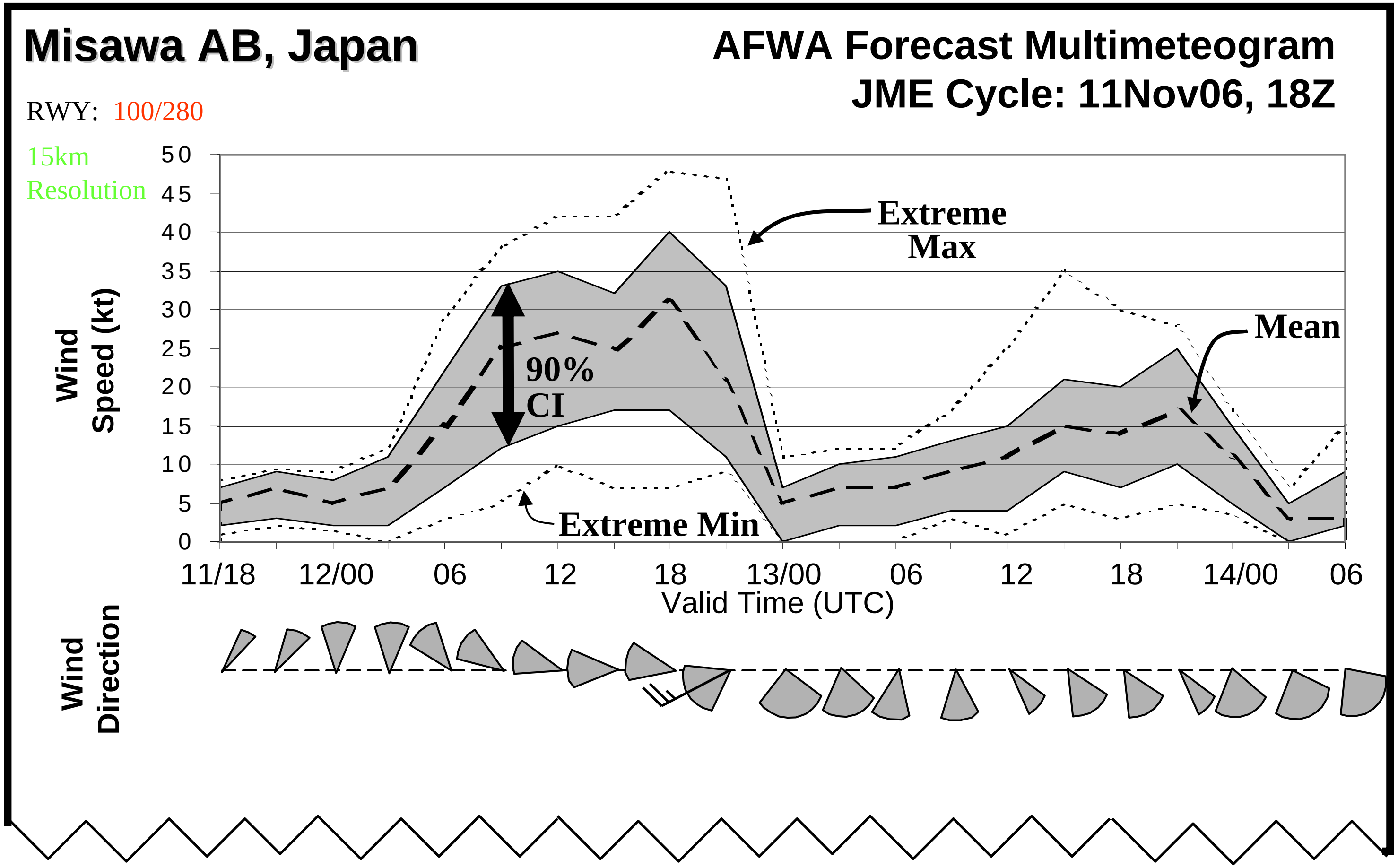
- ORM calculations
- Stop-light style decision inputs
- Portrayal Techniques



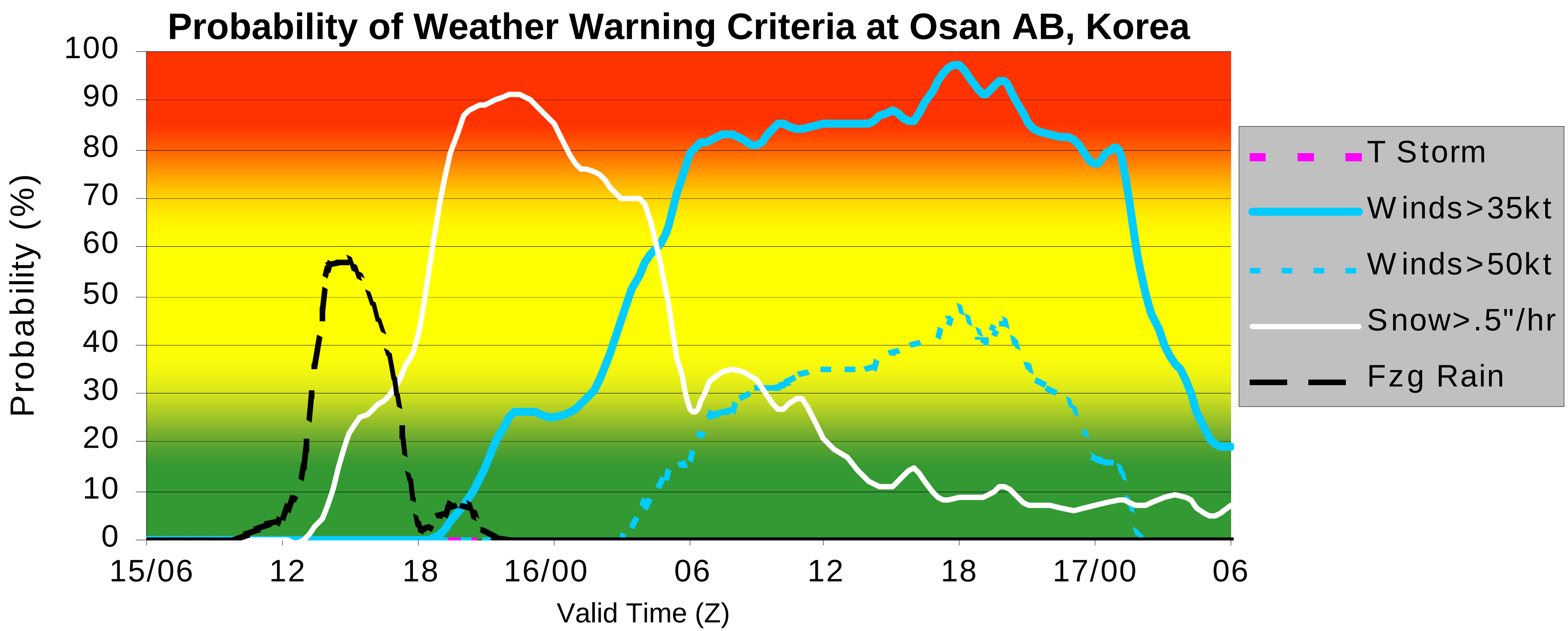
Wx Risk Visualization
(**low** risk tolerance)

Sample JME Product:

Multimeteogram



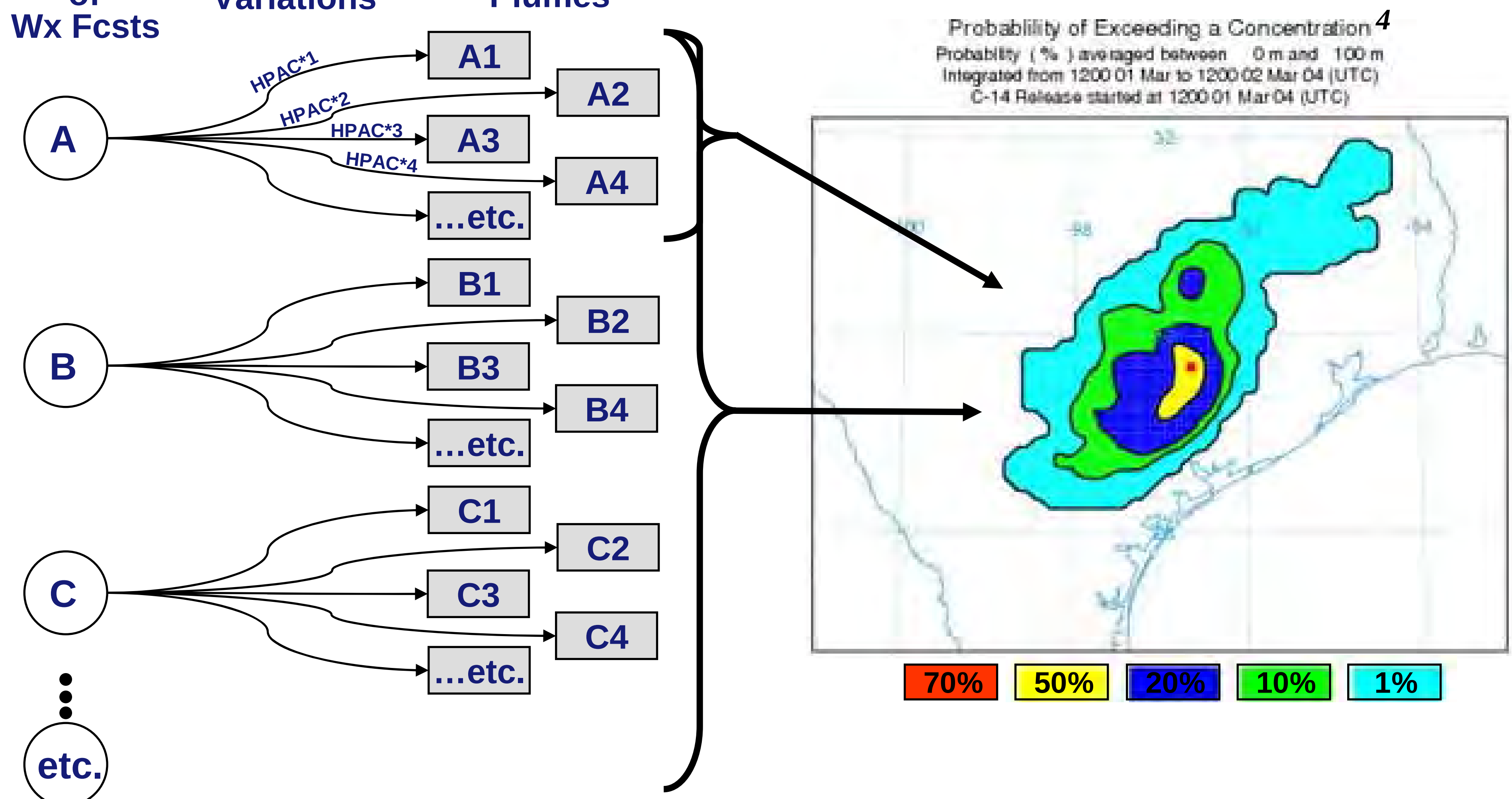
Sample JME Product: Probagram *(Probabilistic Meteogram)*



- **Probability of Lethality for Several Agents**
- **Probability of Threshold Concentration for Several Agents**

Application to Dispersion Modeling

Ensemble of Wx Fcsts | **HPAC Variations** | **Ensemble of Plumes**



Application to Dispersion Modeling

Ensemble of Wx Fcsts

A

B

C

D

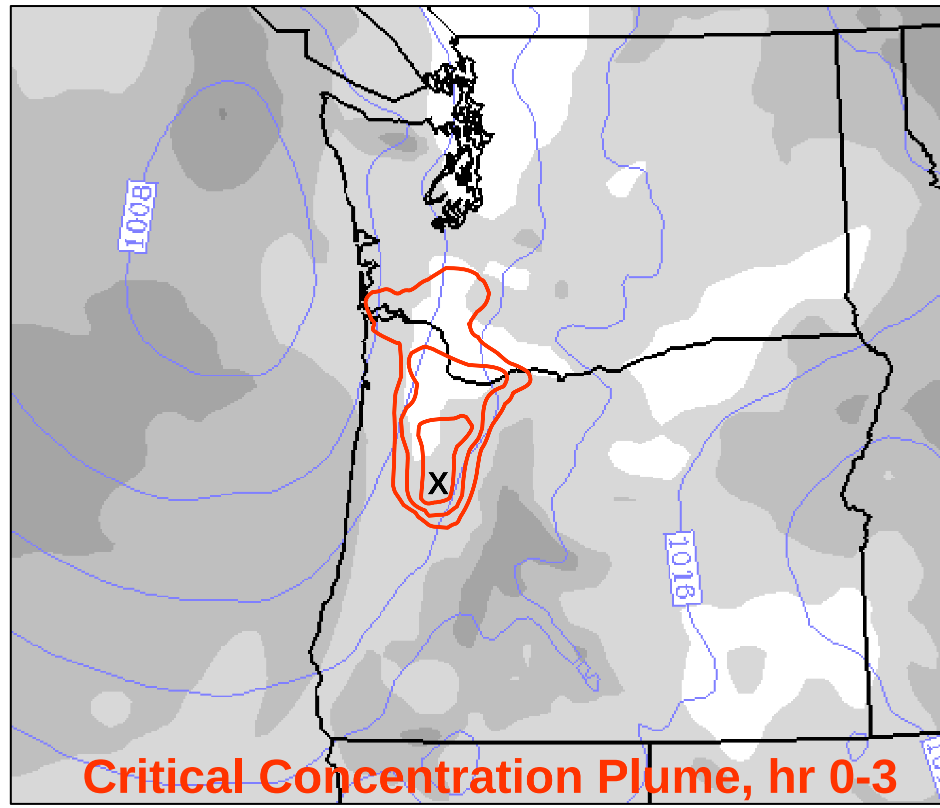
E

F

etc.

"Best Guess" Forecast Winds + Variance

HPAC With Uncertainty Information[5]



HIGH							LOW

Forecast Confidence

Application to Dispersion Modeling

U.S. AIR FORCE

Ensemble of Wx Fcsts

A

B

C

D

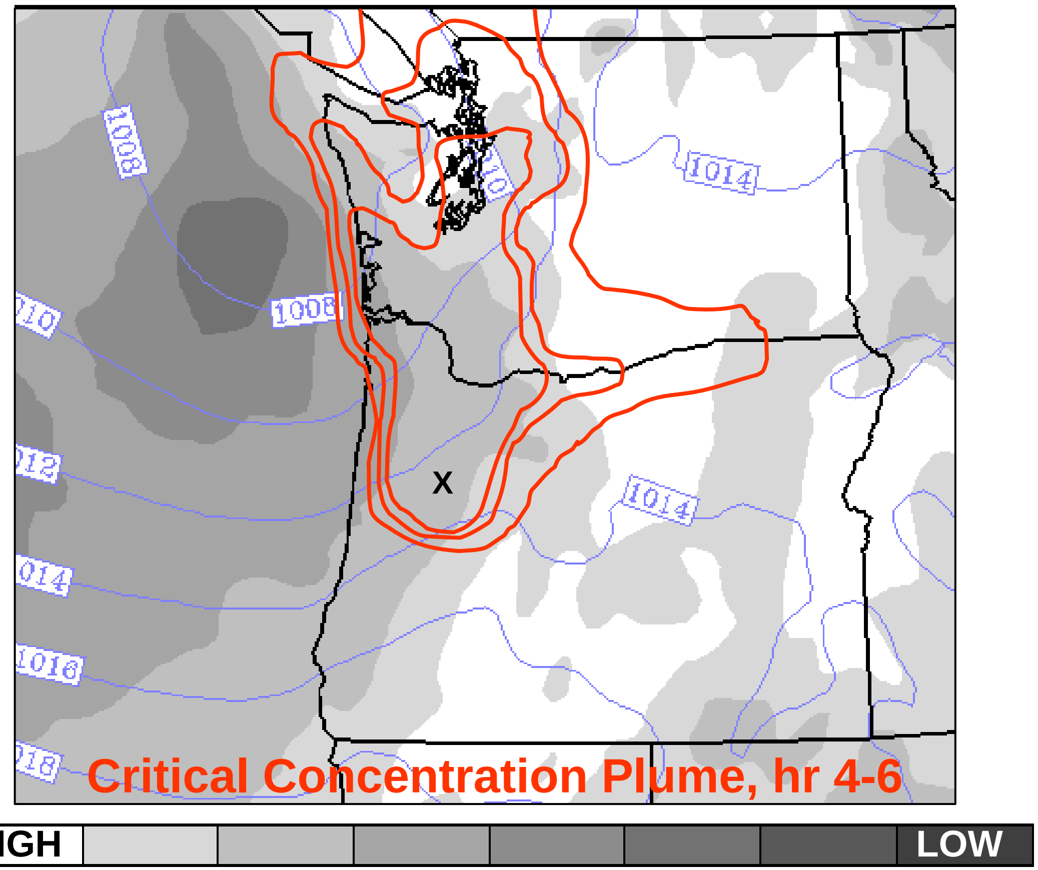
E

F

etc.

"Best Guess" Forecast Winds + Variance

HPAC With Uncertainty Information [5]



Forecast Confidence

Currently Available Forecaster Training

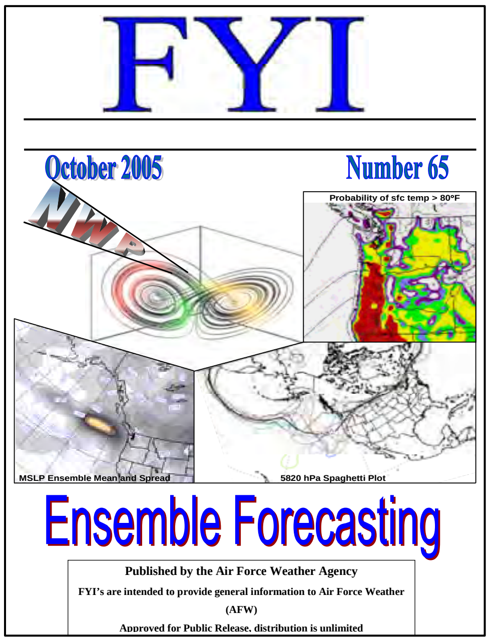
U.S. AIR FORCE

Strengths

- Good for initial exposure
- Starts brainstorm for products and applications ideas
- Available, accessible, free...

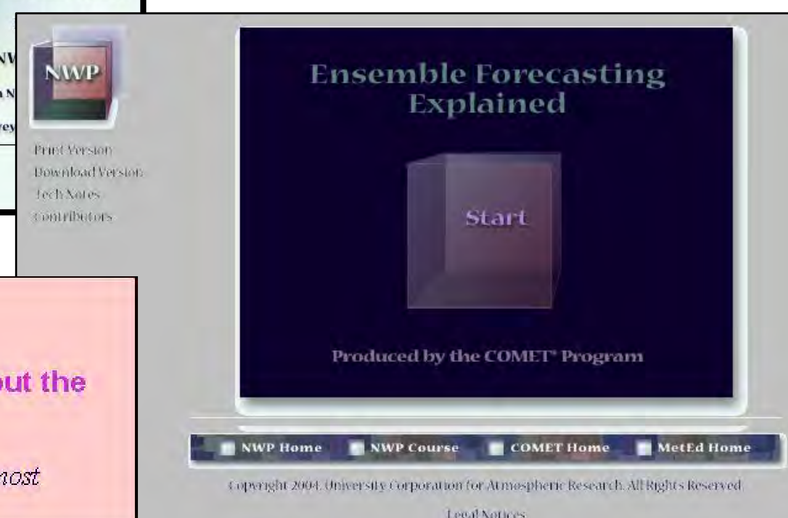
Weaknesses

- Too scientific in places
- Weak on some key concepts
- Leaves forecaster hanging…
  - Limited application to today's forecast process
  - Missing customer interface



Webcast by COMET

COMET module



National Weather Service training manual

ENSEMBLE PREDICTION SYSTEMS

A training manual targeted for meteorologists wanting to know more about the ensemble technique

"Unfortunately when you most need predictability, that's usually when the atmosphere is the most unpredictable." - C. McElroy (NWS)


This ensemble stuff is useless!
Last time they said 80% chance of
snow we didn’t get a flurry
This time they said only 40%!

Warfighter Education on using Stochastic WX

- Warfighters should understand :
  - Benefits of stochastic vs. deterministic weather to ORM decision making
  - Optimal use of stochastic weather in both M2M and human decision making

- Recommend integration with warfighter training (i.e. schools, exercises, etc.)

Stochastic WX Optimizes ORM

Defensive ORM: Resource Protection

Scenario – *Typhoon Approach at Kadena AB, Japan*

Critical Event: Surface Winds ≥ 50kt **-- Damaging to aircraft parked on the apron**

Loss (if damaged): $1M

Cost (of protecting): $150K -- Redeployment (fuel, TDY costs, etc.)

***Example Expense Over 2 Year Period**

Typhoon Approach	**Deterministic Operator** (Decision Threshold = 50kt)			**Stochastic Operator** (Decision Threshold = 15%)		
	Forecast Wind (kt)	Observed Wind (kt)	Cumulative Expense ($K)	Forecast Wind > 50kt	Observed Wind (kt)	Cumulative Expense ($K)
1	12	20	0	9%	20	0
2	36	44	0	17%	44	150
3	77	81	150	99%	81	300
4	43	62	1150	25%	62	450
5	52	41	1300	33%	41	600
6	28	29	1300	24%	29	750
7	20	27	1300	1%	27	750
8	32	23	1300	7%	23	750

*Generated by computer simulation

Defensive ORM: Resource Protection

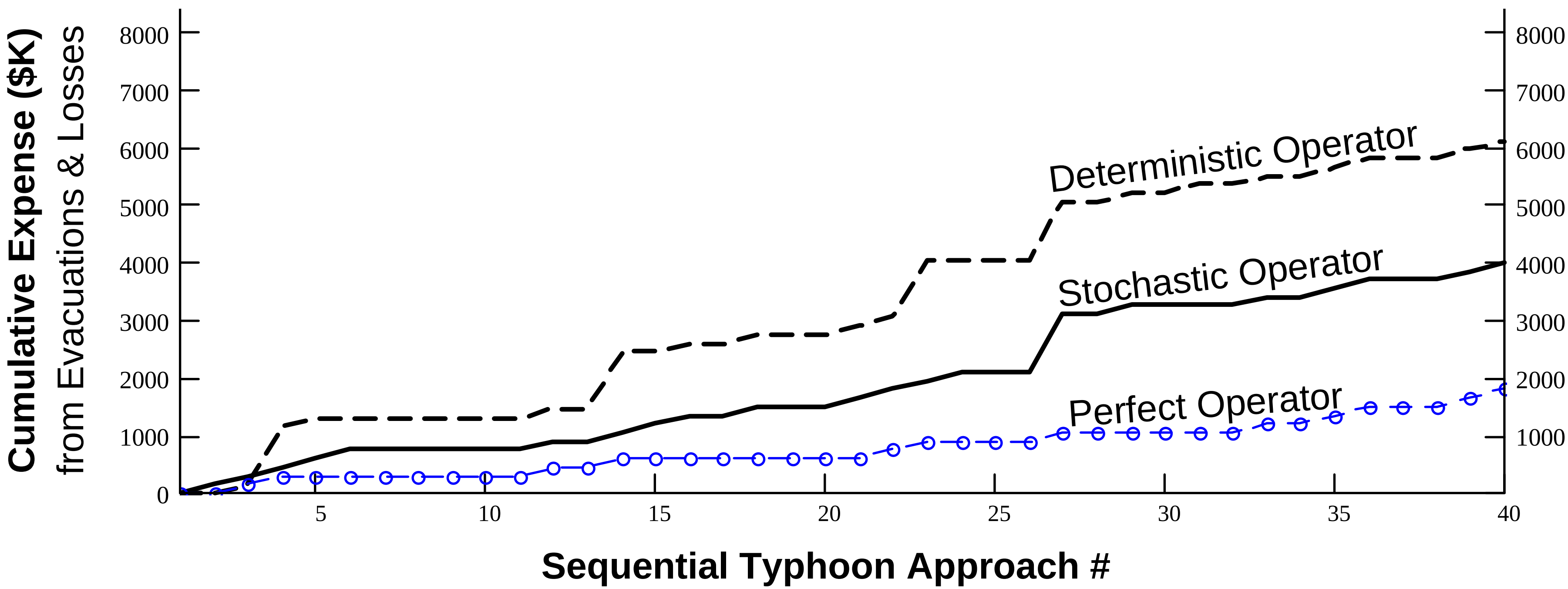
Scenario – *Typhoon Approach at Kadena AB, Japan*

Critical Event: Surface Winds ≥ 50kt **-- Damaging to aircraft parked on the apron**

Loss (if damage): $1M

Cost (of protecting): $150K -- Redeployment (fuel, TDY costs, etc.)

*Expense Over 10-Year Period



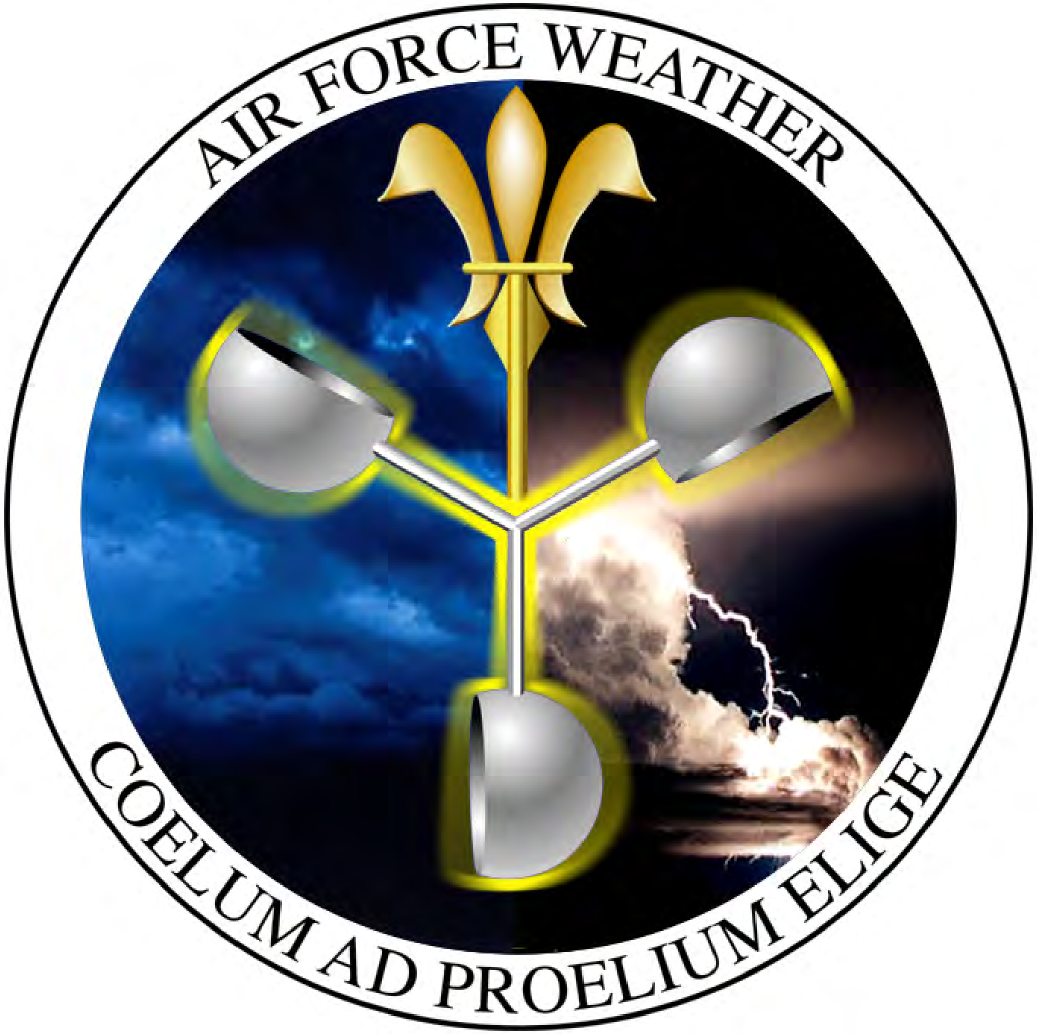
*Generated by computer simulation

Summary

- **Ensemble forecasting provides objective stochastic weather**
  - **Technology well advanced, and can enable ORM…<u>not just in a military setting</u>**
- **Ensemble Capability is Coming…**
  - **JEFS results late 2008 will pave the way for future operational EPS**
  - **Joint prototype with Navy will create a DoD asset**
- **Education and training required to fully realize advantages**
  - **Forecaster – retrain to stochastic thinking**
  - **Warfighter – foster integration and exploitation of stochastic weather**

"Stochastic weather allows us to exploit uncertainty,
…rather than being at its mercy."

--- F. Anthony Eckel, Maj (PhD)



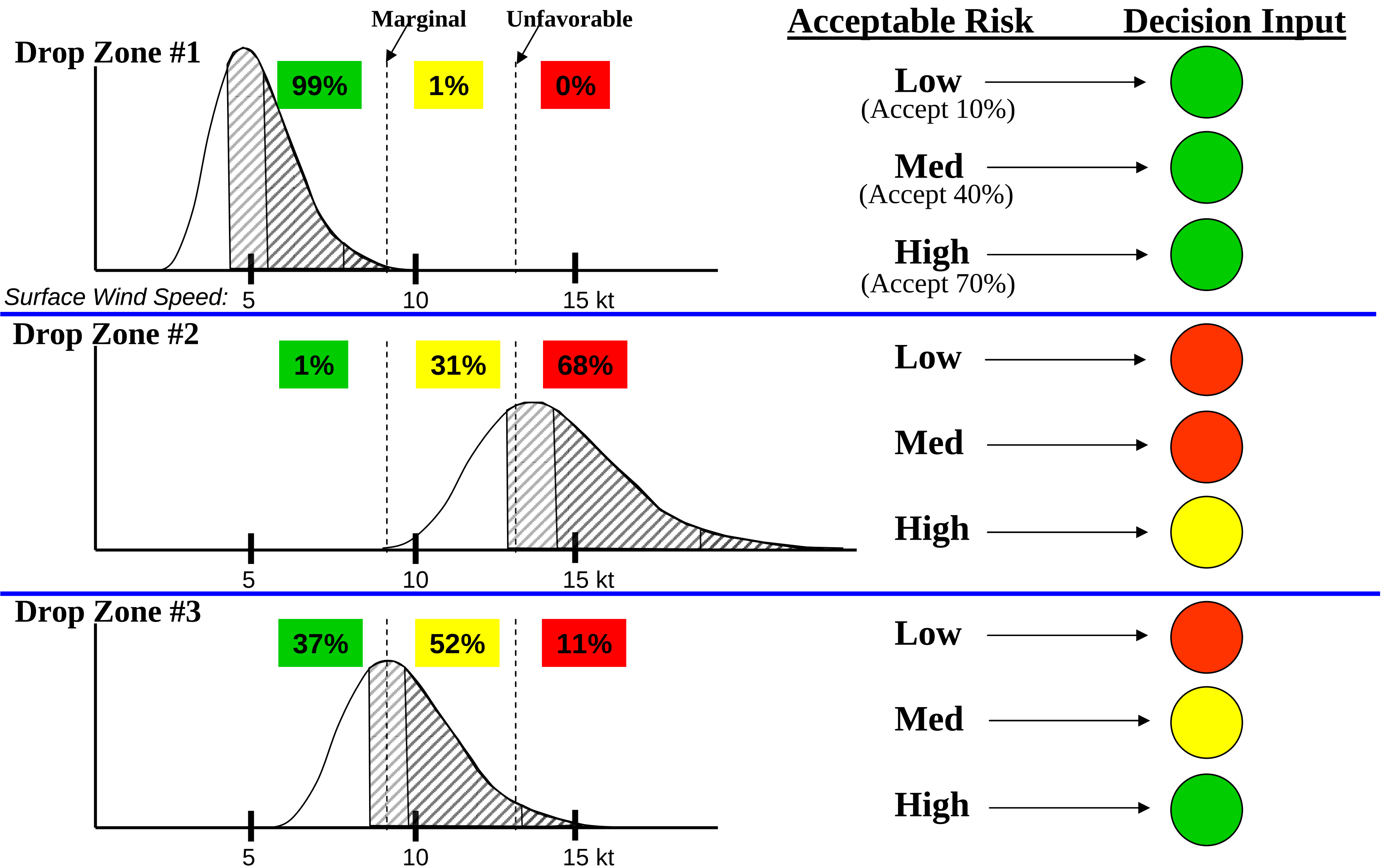
“Anticipate and Exploit the Weather for Battle”

Backup Slides

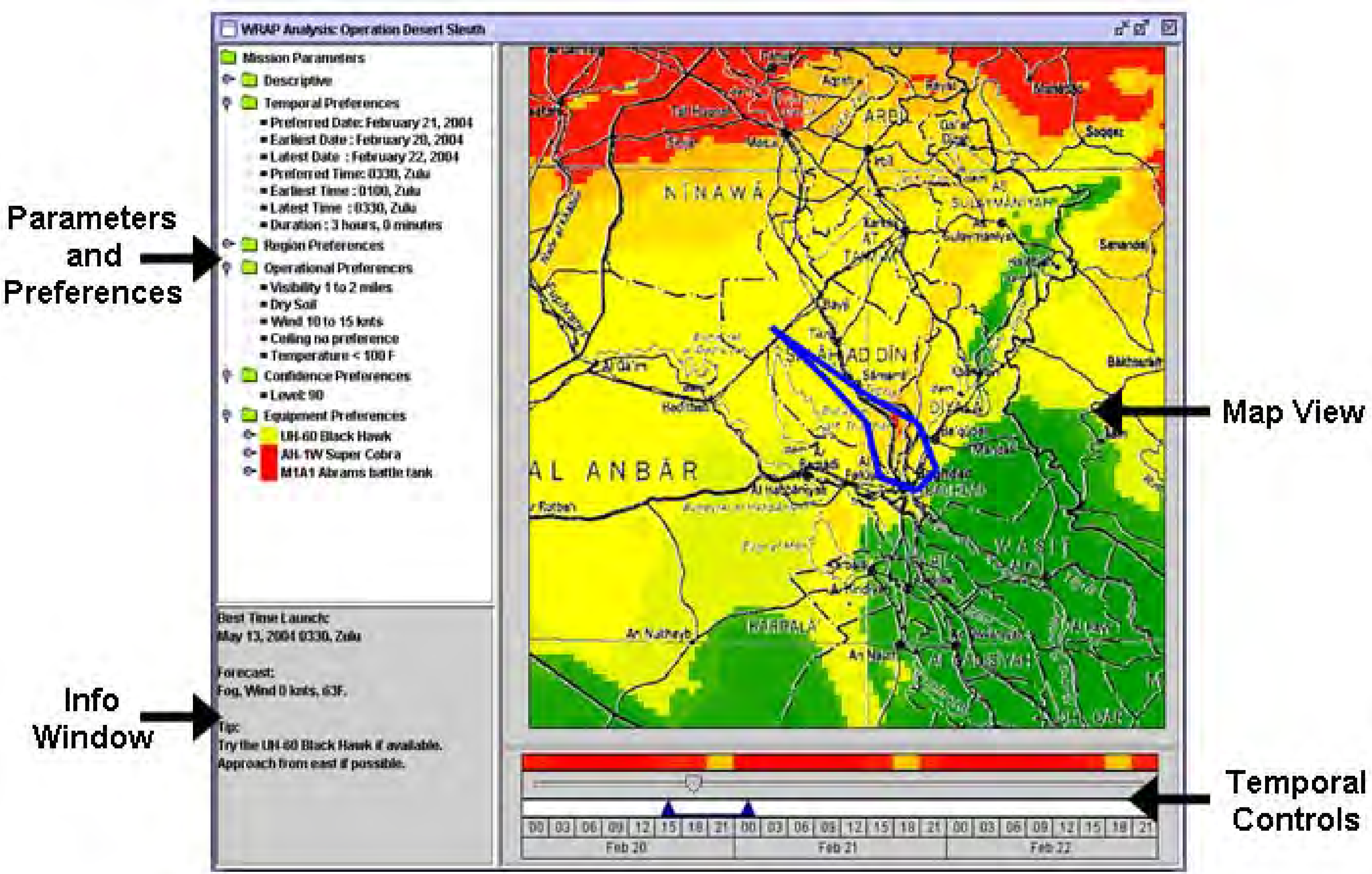
Notional Requirements for NWS Ensemble Data (by 2010)

	CONUS (WRF) Limited Area Ensemble	Global Mesoscale Ensemble
Model Domain	1) CONUS (20N-55N, 135W-60W 2) Alaska (55N-73N, 170W-130W)	Global
Grid Spacing	10 km	25 km or spectral equivalent (~T565) with step down resolution beyond 48-h forecast lead time
Number of Levels	60	40
Ensemble Size	20 Members	20 Members
Cycle Frequency	4 per day	4 per day out to 72 h, with 2 of those cycles out to 240 h
Forecast Length/Interval	48 h / 3 h	72 h & 240 h / 6 h
Delivery Schedule	Incremental delivery starting NLT 3h after initialization time, complete NLT 5h after initialization time	*same*
Analysis Perturbations	Robust initial conditions (Ex: Ensemble Transform Kalman Filter)	*same*
Model Perturbations	Robust accounting for model uncertainty using single model framework with multiple physics combinations, physics perturbations, and/or stochastic physics.	*same*
Calibration	Robust correction for systematic errors, both 1st moment (bias correction) and 2nd moment (spread correction) of the ensemble distribution	*same*

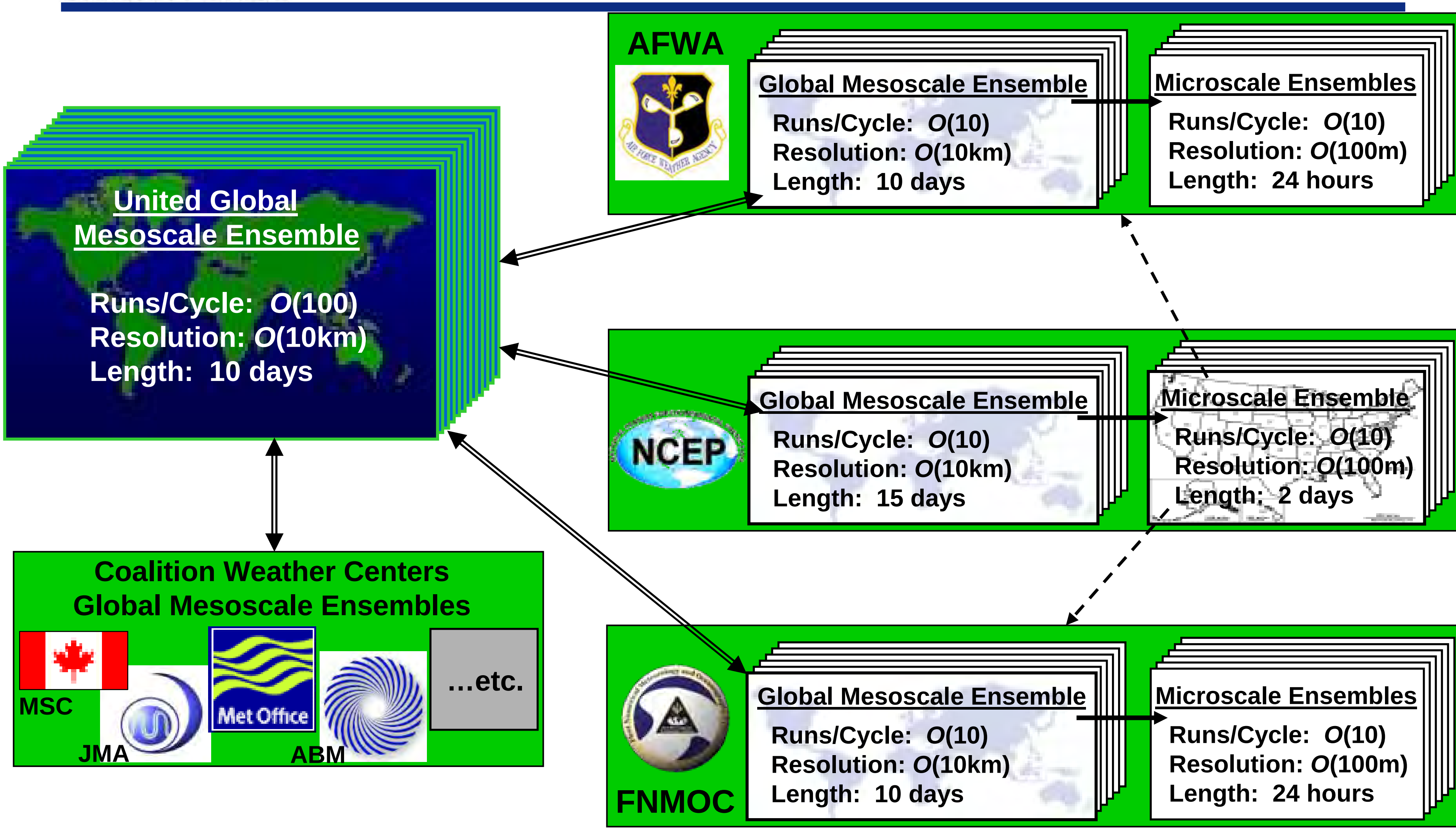
WRAP Decision Input Processing



WRAP Interface



Long Term EF Vision (2020)



Quantum-Chemistry Theory Modeling of Chemical Warfare Agent/Adsorbent Interaction

Threat Agent Science – BA06TAS001
DTRA Program Manager: Dr. Frank Handler

Lt Jennifer Plourde
Air Force Research Lab

Tom J. Evans, Ph.D.
Cubic Defense Applications

Purpose for the Work

Experimental work with chemical warfare agents (CWA) is dangerous and expensive

- Only a few specially-equipped and –staffed laboratories perform CWA work
- High cost associated with CWA work
- Both factors limit the rate of study and characterization
- Increases the difficulty in dealing with the emergence of new threat agents (NTA)

Purpose for the Work

Experimental work often relies on the use of relatively-safe simulants

The degree to which these simulants correlate to specific agent behaviors is:

- Often unknown
- Directly correlated to specific properties/interactions
- Is never complete

Purpose for the Work

Goal: Gaining insight into the characteristics of CWA without the cost and risk.

Benefits of QCT

Quantum-Chemistry Theory (QCT) has been proven as a reliable approach for making *quantitative* predictions of molecular properties and characteristics

Benefits of QCT

QCT can be used to model the adsorption and reaction of CWA on surfaces

- Provides a means for understanding and predicting fate of agent
- Allows for the comparison of agents and simulants, leading to the evaluation, intelligent use and improvement of simulants
- Enables the quick assessment of new, previously-unknown CWAs
- Provides the enabling processes for a “materials-by-design” approach to CWA protection and remediation

Benefits of QCT

QCT is an aid to, not a replacement for, experimentation

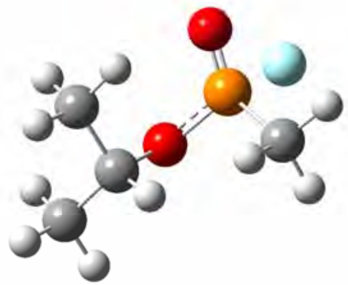
- QCT is a means for making the most efficient use of laboratories that can perform CWA work
- QCT calculations can easily be done to test ideas prior to experiment work

Approach

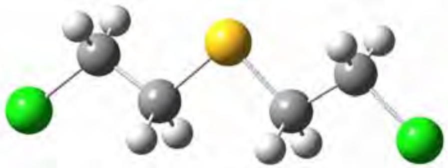
- Use Density Functional Theory (DFT) or post-Hartree Fock corrections (Møller-Plesset) to include electron correlation
- Utilize realistic models for reactive surface sites on operationally-relevant oxides: γ-Al_2O_3 and a-SiO_2
- Validate models by comparison of observed and calculated properties of species adsorbed on oxide surfaces
  - μ-wave Spectra
  - IR Spectra
  - ΔH_{ads}
  - Adsorption Geometries
- Compare adsorption behavior of real agents and simulants

Agents and Simulants of Interest

Agents

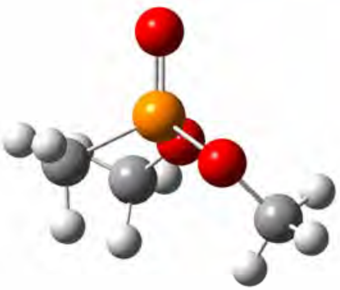


Sarin (GB)



Sulfur Mustard (HD)

Simulants



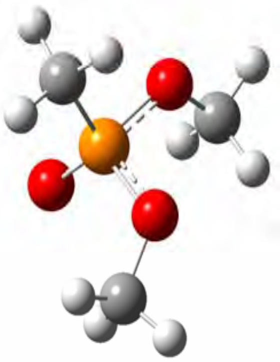
DMMP

2-CEES

QCT Treatment of Free Molecules

How well do QCT methods calculate properties of free molecules?

DMMP



DMMP Rotational Constants (MHz)

Method	A	B	C
Experiment[1]	2828.753	1972.359	1614.268
B3LYP/6-31G*	2685.67	1943.79	1579.29
MP2/6-31G*	2714.42	1957.53	1600.19

<u>Calculated vs. observed gas phase μ-wave spectra for DMMP</u>

- Calculations use MP2 and DFT (B3LYP) approaches
- Relatively small basis sets (6-31G*)

→Good agreement with experimental results

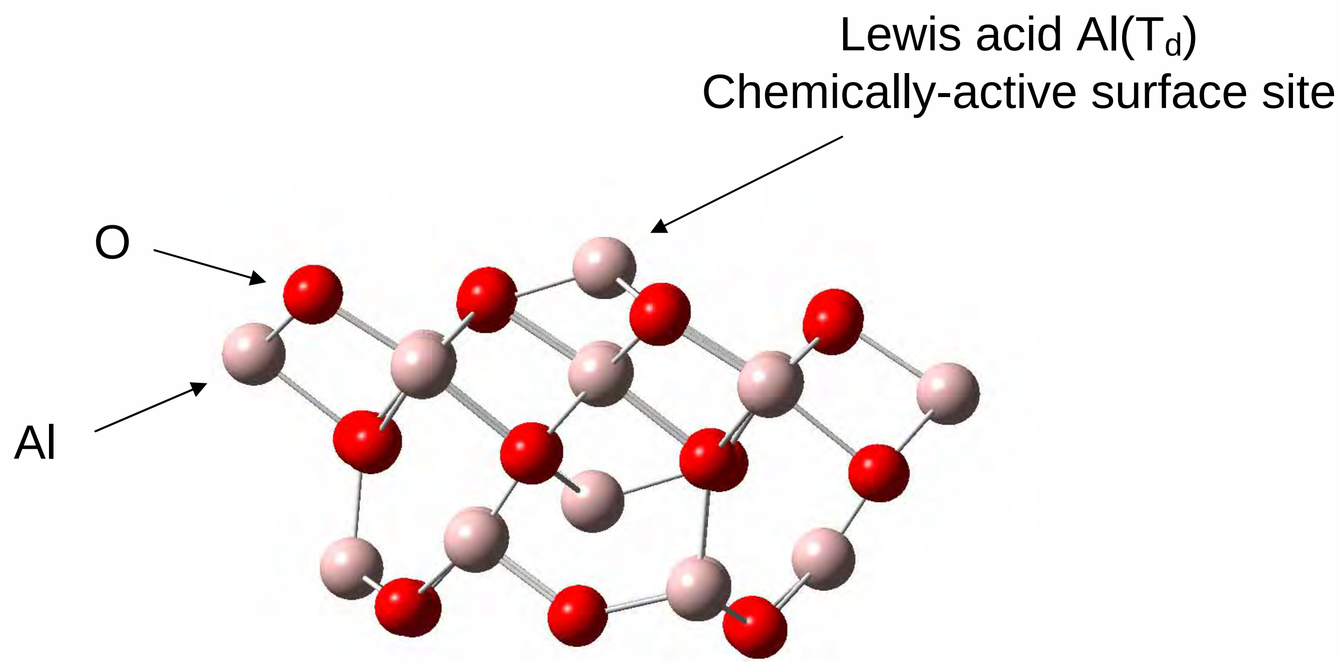
1. Suenram, et. al., *J. Mol. Spectrosc*. **211**, 110 (2002).

Systems of Interest

- Adsorption of agents and simulants on γ-Al_2O_3[2] and on OH-terminated a-SiO_2[3]
- Systems are fairly well understood – Calculated results can be compared to experiment[4-6]
- γ-Al_2O_3 and a-SiO_2 are important adsorbents – many other materials are based on a silicate or aluminosilicate chemical composition

2. Pinto and Elliott, *Phys. Rev. B* **70**, 125402 (2004).
3. Van Ginhoven et al., *Phys Rev B* **71**, 24208 (2005).
4. Mitchell, et al., *J. Phys. Chem. B* **101**, 11192 (1997).
5. Kuiper, et al., *J. Catal.* **43**, 154 (1976).
6. Kanan and Tripp, *Langmuir* **17**, 2213 (2001).

Model γ-Al_2O_3 Surface



- Cluster cut from semi-infinite crystal surface
- Different cluster sizes will be studied to evaluate size effects
  - Al_8O_{12} and $Al_{20}O_{30}$

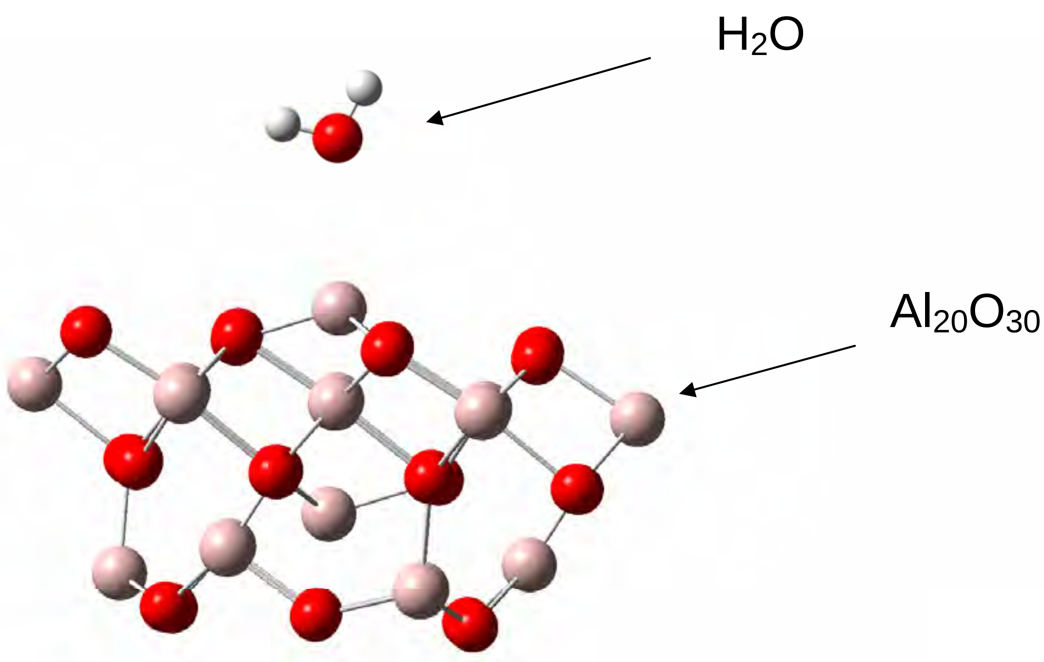
Substrates on γ-Al_2O_3 Surface

- Al active site allowed to relax during interactions with substrate
  - Displacement should be on the order of ~0.3 Å
- Heat of adsorption:
  - ΔH_{ads} = E(cluster + substrate) – E(cluster) - E(substrate) + E(BSSE)

E(BSSE) = Counterpoise correction for basis set superposition error

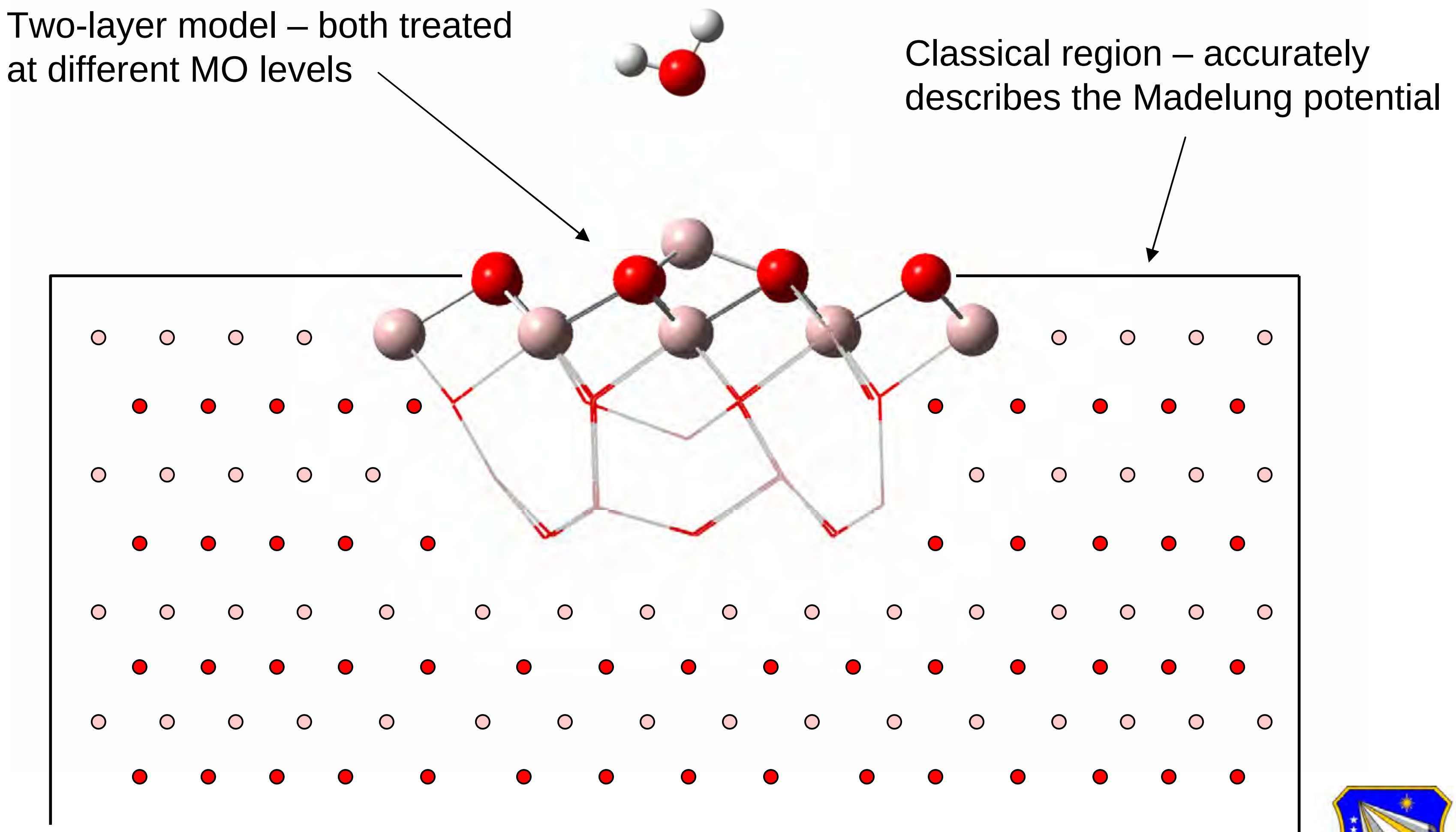
Testing γ-Al_2O_3
Physisorption of H_2O on γ-Al_2O_3

<u>Cluster Calculation</u>
•DFT (B3LYP)
•Optimize: relatively large basis for H_2O and Al_8O_{12} – small for the rest.
•Single-point calculation – large basis for all



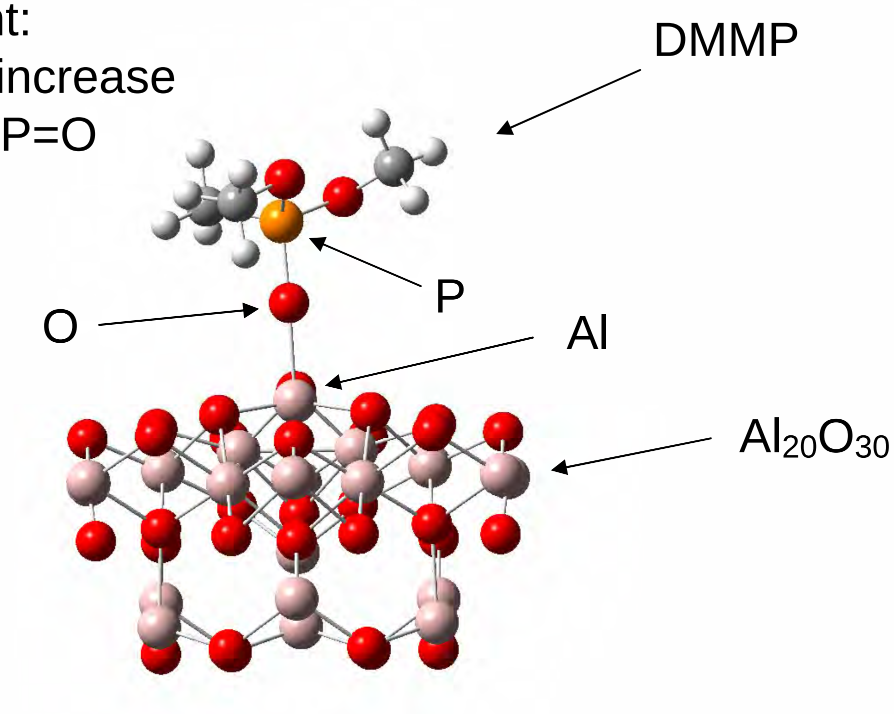
Difficult test case – polar adsorbent

ONIOM/SCREEP



Agent/Simulant Interactions with γ-Al_2O_3

Comparison to experiment:
Adsorption should cause increase in frequency (red shift) of P=O



No other frequencies should undergo large changes

ΔH_{ads} calculations will be used to compare different adsorption geometries:
Lowest ΔH_{ads} indicates correct relative geometry

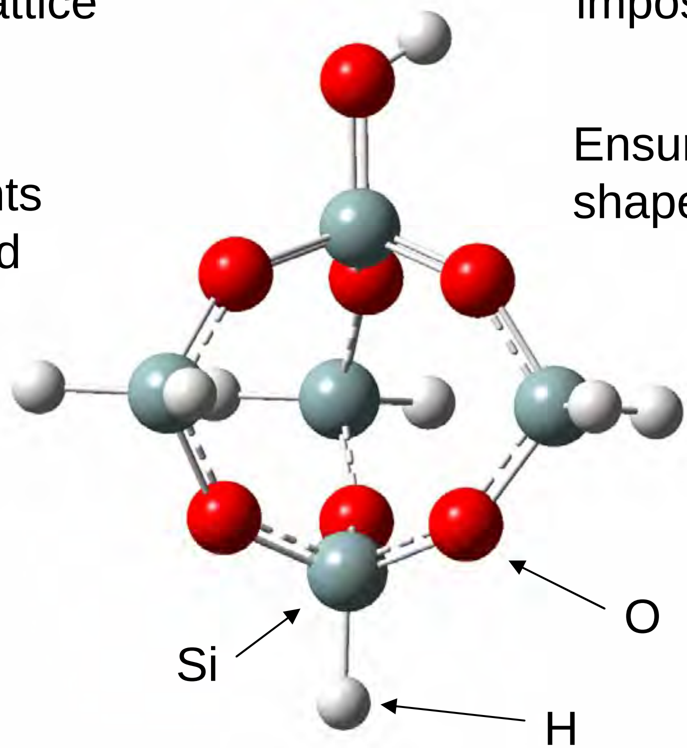
Model a-SiO_2 Surface

Cluster representation of the overall a-SiO_2 lattice

Without the bulk, structural constraints need to be imposed

C_s symmetry (plane) imposed during optimization

Ensures the cluster keeps the shape it would have in the bulk

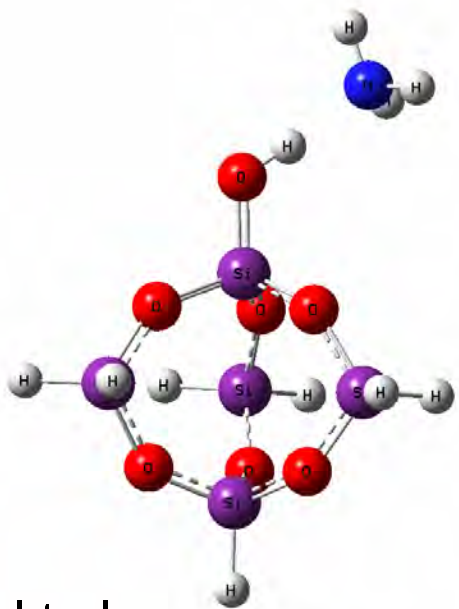


Si_5O_7 Cluster

Model a-SiO_2 Surface

This system has C_s symmetry.

Almost any agent or simulant of interest will not have C_s symmetry.



Anharmonicity determined to be important.

Shortcoming of the B3LYP functional may be overcome with a better functional.

Future Directions

- Beyond free-standing Al_2O_3 clusters
  - Use embedding techniques to include lattice Madelung potential
  - Results to date suggest that substrate/cluster interactions are overestimated
  - Could affect absolute ΔH_{ads} but not agent/simulant comparison
- DMMP and Sarin SiO_2
  - Previous problems with getting shift of the SiO-H stretching mode solved by imposing C_s symmetry
  - Investigate DFT vs. MP2 treatments of hydrogen bonding
- Effects of Substrate Modification
  - Include hydration of Al_2O_3 surface to form –OH sites
    - Will permit studies of hydrolysis reactions relevant to agent fate
    - Sulfur Mustard (HD) and 2-CEES can be studied. 2-CEES reacts via

$$-CH_2Cl + HO\text{-}Al \rightarrow -CH_2\text{-}O\text{-}Al + HCl$$

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Information Systems: The Key to Future Force Success in a CBRN Environment

January 9, 2007

PRESENTED TO:
2007 CBIS Conference
Austin, Tx

Edward Wack
Director of Future Acquisition
JPEO-CBD
(703) 681-9607

Presentation Outline

- Who we are, what we do
- Major Defense Acquisition Programs (MDAPs)
- System of Systems (SoS) Development
  - US Army Future Combat Systems (FCS)
- Future Needs
- Summary

Organizational Structure

- **Defense Acquisition Executive (DAE)**
  - **Army Acquisition Executive (AAE)**
    - **Joint Program Executive Office for Chemical and Biological Defense**
      - Deputy JPEO Medical Systems
      - Special Assistants for External and Internal Affairs
      - Chief of Staff

JPMs

- BIOLOGICAL DEFENSE – COL Daniel Berry
- CB MEDICAL SYSTEMS – COL David Williams
- CONTAMINATION AVOIDANCE – COL Kyle Burke
- COLLECTIVE PROTECTION – Mr. Stan Enatsky
- DECON – Mr. Will Hartzell
- GUARDIAN – COL Mark Malatesta
- INDIVIDUAL PROTECTION – Mr. Jim Nelson
- INFORMATION SYSTEMS – Mr. Scott White

DIRECTORS

- KNOWLEDGE MANAGEMENT – Mrs. Brenda Besore
- BUSINESS OPERATIONS – Mr. C.H. Cutshall
- MANAGEMENT SUPPORT – Mrs. Susan Hubbard
- CURRENT ACQUISITION – Mr. Gary Olejniczak
- FUTURE ACQUISITION – Mr. Edward Wack
- HUMAN RESOURCES – Ms. Linda Yeck

Army
Marines
Navy
Air Force

Future Acquisition Directorate

Mission

Enable CBRN defense solutions that allow the Warfighter to accomplish their mission

Goals

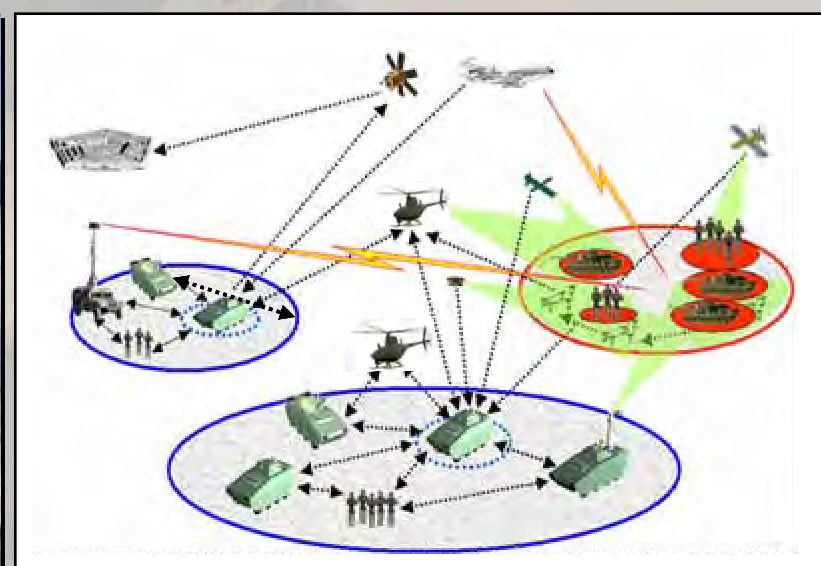
Guide the development of CBRN defense solutions in support of anticipated or articulated future capability requirements through analysis, experimentation, advocacy and coordination

Objectives

- Define future systems concepts and architectures
- Technology assessments for JPEO and JPMs
- Transition CBRN defense solutions to customers, including MDAP PMs and JPMs
- Synchronize and integrate capabilities across JPMs

Future of CBRN Defense

- **Net-Centric CB Defense Architecture**
  - **A family of Integrated Systems (Sensors, Information Systems, Protection Systems, Consequence Management Tools)**
  - **Continual or On-demand Access to Data Through Various Ports and Peripherals on the network**
  - **<u>Shared Awareness, Increased Speed of Command, and Self Synchronization</u>**
  - **Interoperable and Seamless Capability that Provides Exponentially Increased Military Benefit to Those Systems/Soldiers that Otherwise Operate Independently**



Major Defense Acquisition Program Chemical/Biological Defense Program Support

Expeditionary Fighting Vehicle

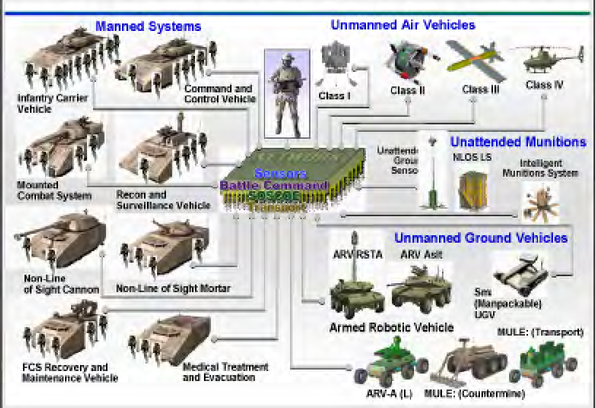
CBRN REQUIREMENTS

CBR Detection
Battle Management
Integrated Early Warning
Collective Protection

Decontamination
Individual Protection

Stryker

FUTURE COMBAT SYSTEMS



OTHERS

Bradley, THAAD, CFPI, UAV...

Joint Strike Fighter

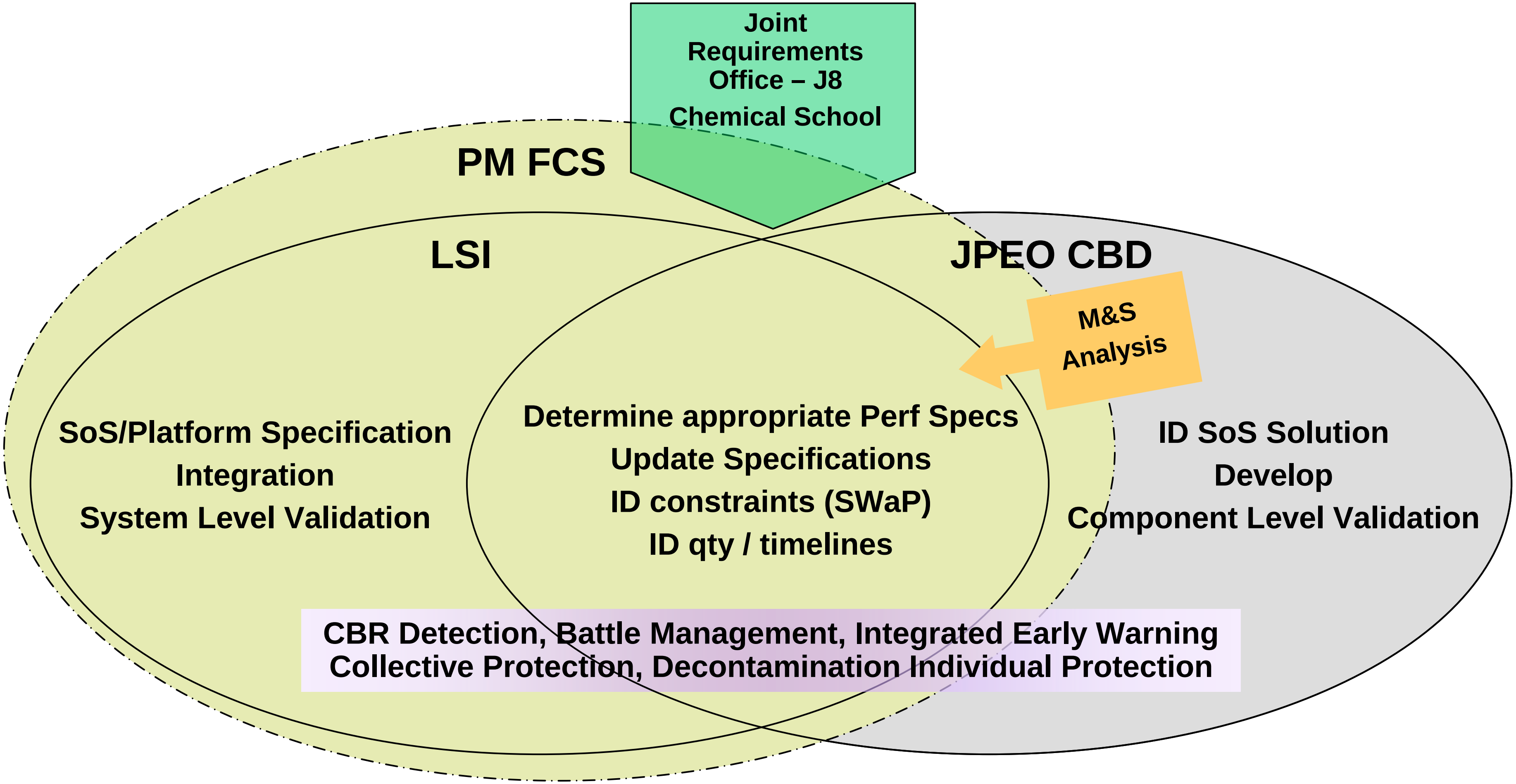
FCS CBRN Objective and Goals

Objective: Develop and demonstrate SoS solution that integrates into the FCS architecture and provides the FBCT a capability to accomplish their missions unencumbered by CBRN hazards

Goals:

- In the absence of hazard, the CBRN SoS solution should impose minimal burden
- Solution should leverage strengths to improve situational awareness, response and BCT mission effectiveness
  - ISR assets (CBRN sensors, HUMINT, disparate sensors)
  - Platforms (air, grounds, manned/unmanned)
  - Network and communications
  - Computing capacity

FCS-LSI-JPEO Interaction



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Developing Systems

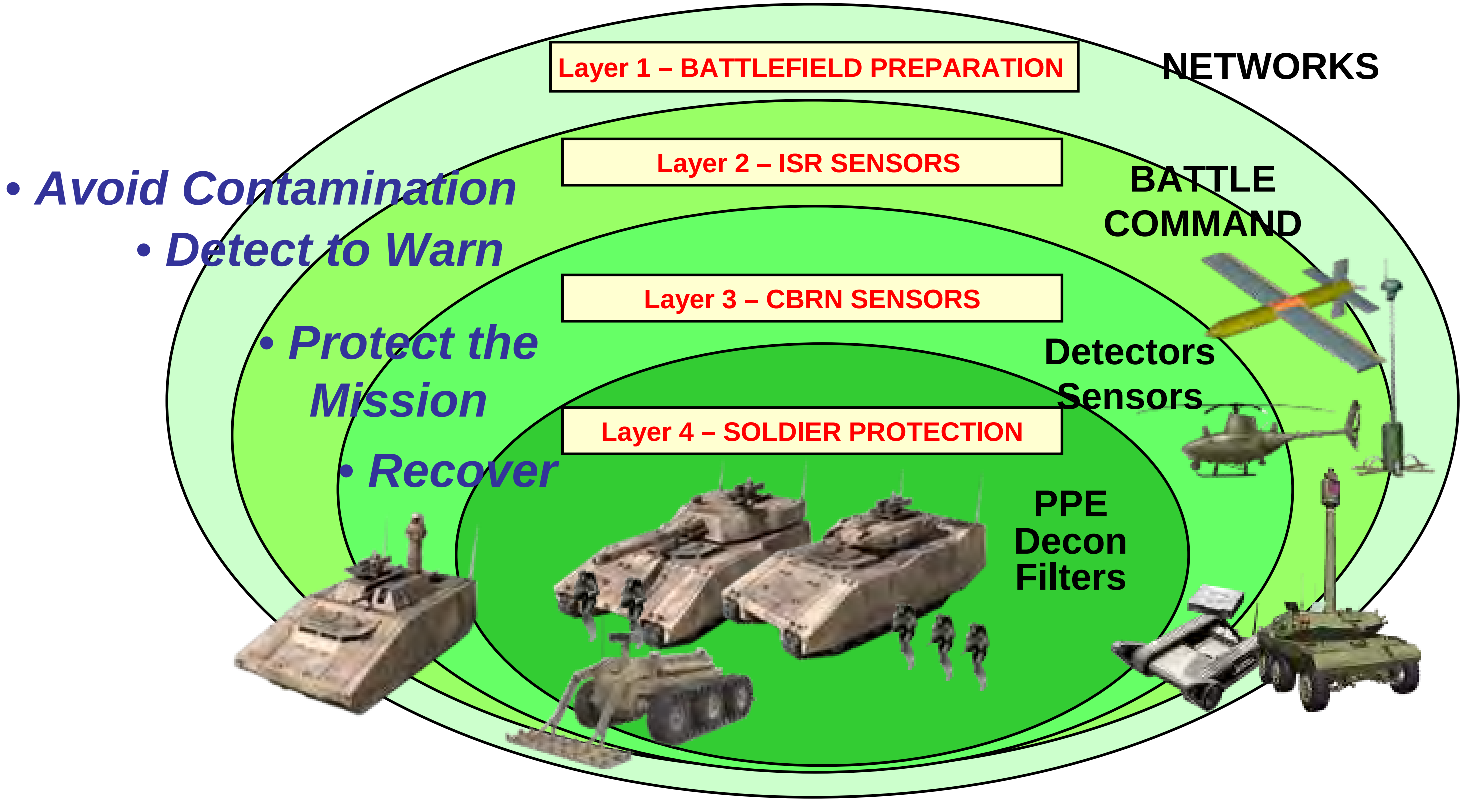
Mission
Outcomes and Objectives
Resources and Constraints
Environment

Threat
Overt, Covert
Large, Small
Chem, Bio, TIC, NTA

Required System Capabilities
Sufficient Warning
Protective Response
Minimal Degradation in Mission

System Architecture
Component Performance
Connectivity
Platforms
CONOPs

FCS Layered CBRN Architecture



All Layers Required for CBRN Protection

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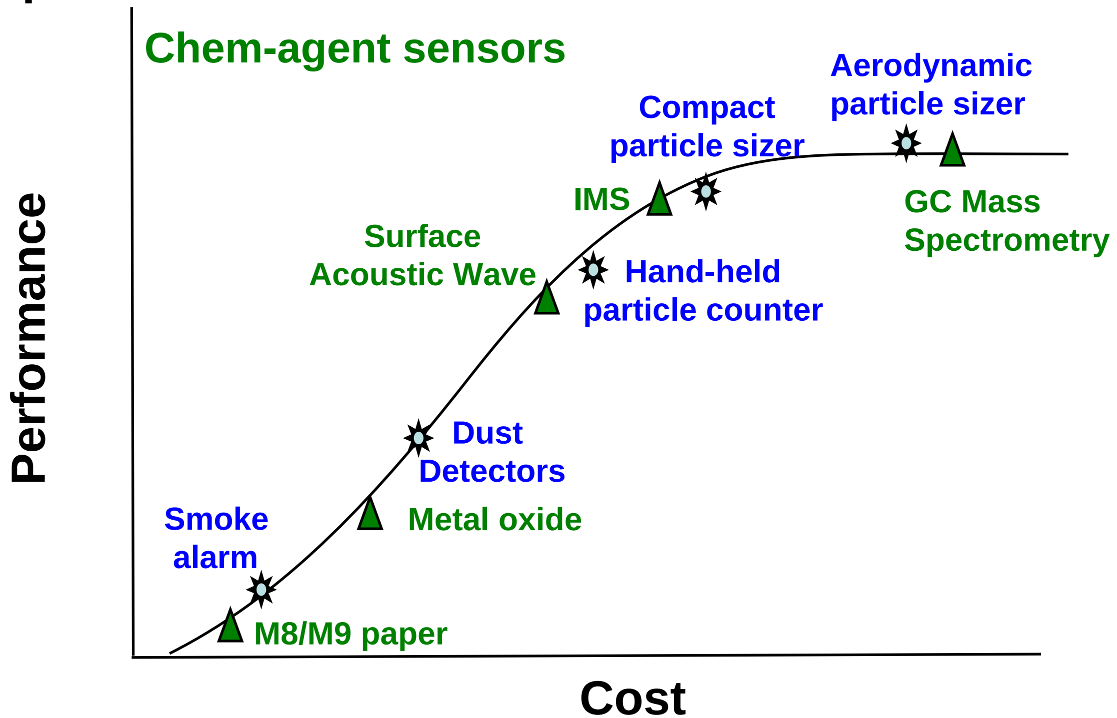
Chem/Bio Defense Technology Performance Trends (Notional)

Examples: Particle detectors

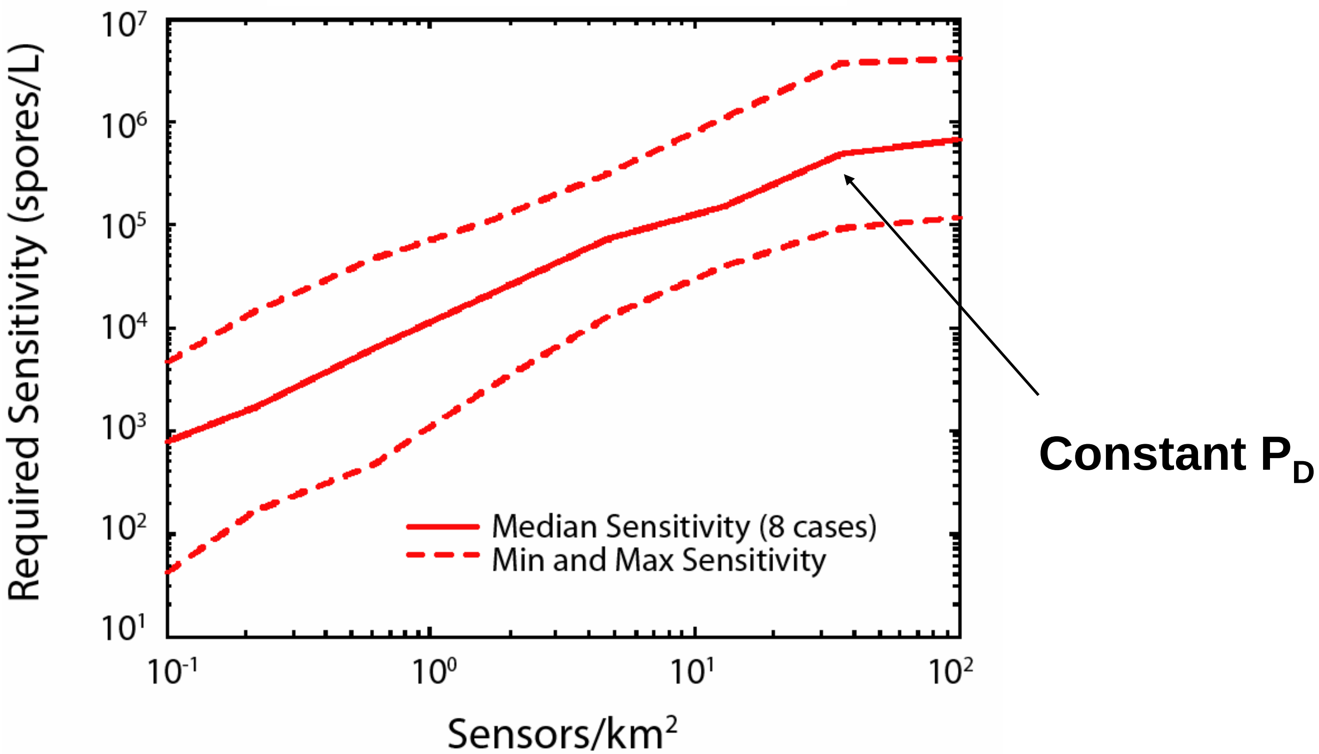


- **Given mission, threat and system performance goals, which combination of sensor types is optimal**

Challenge: Develop sensing <u>systems</u> whose performance and cost are matched to problem being addressed

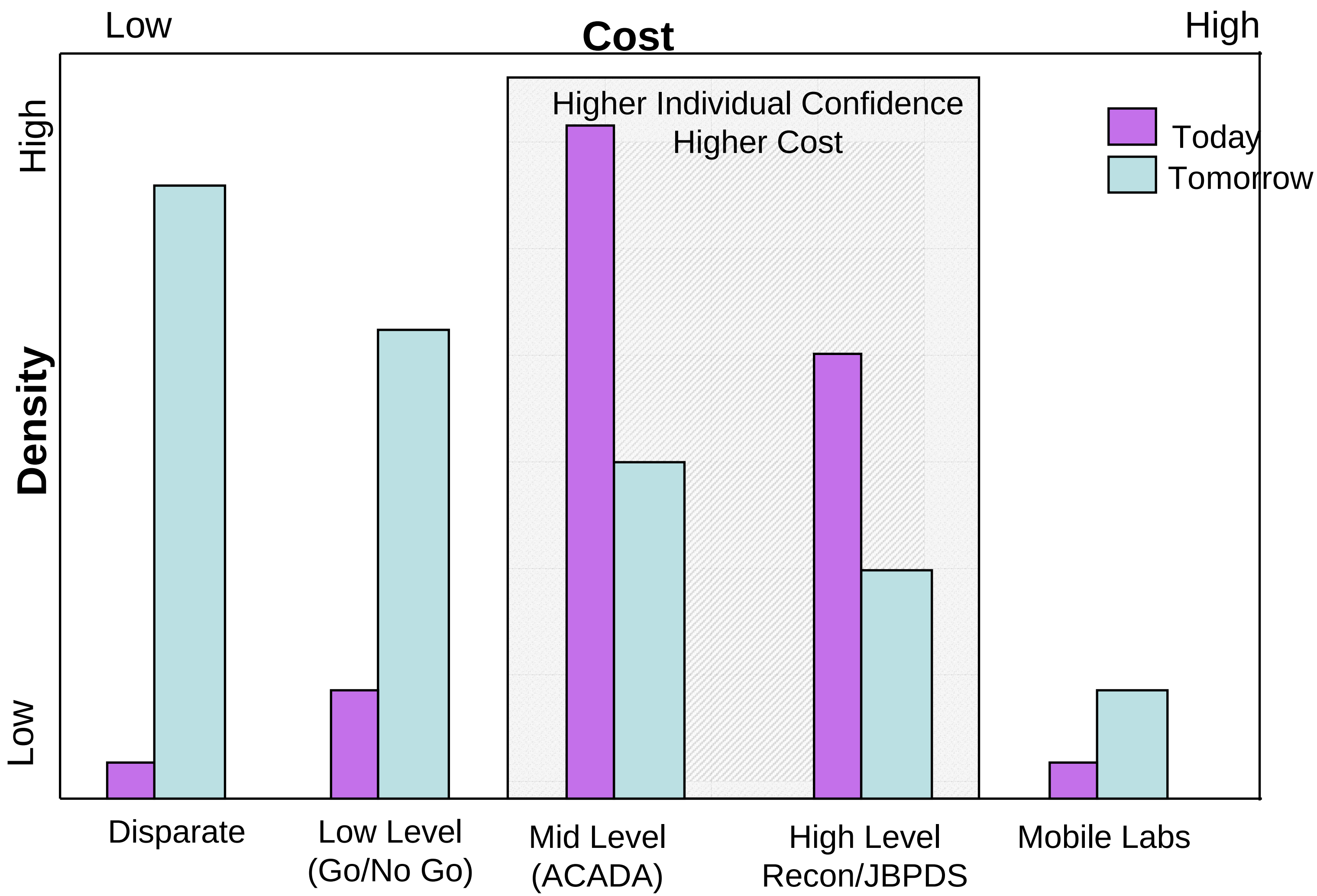
Optimization of Sensing System Parameters

Example:
HPAC simulation
1 kg *B Anthracis* mass
8 weather conditions
Point burst release



- **Sensor performance requirements can be traded against sensor density**
- **Probability of system false alarm can be kept low through intelligent fusion algorithms**
- **Performance and cost of system can be optimized through hybrid sensing architectures, layered or cued sensing, and information fusion**

Future Battlefield Sensor Concept



The same investment and the right combination of networked detectors achieves equivalent performance and covers more of the battlefield

Implications and Development Needs (1 of 2)

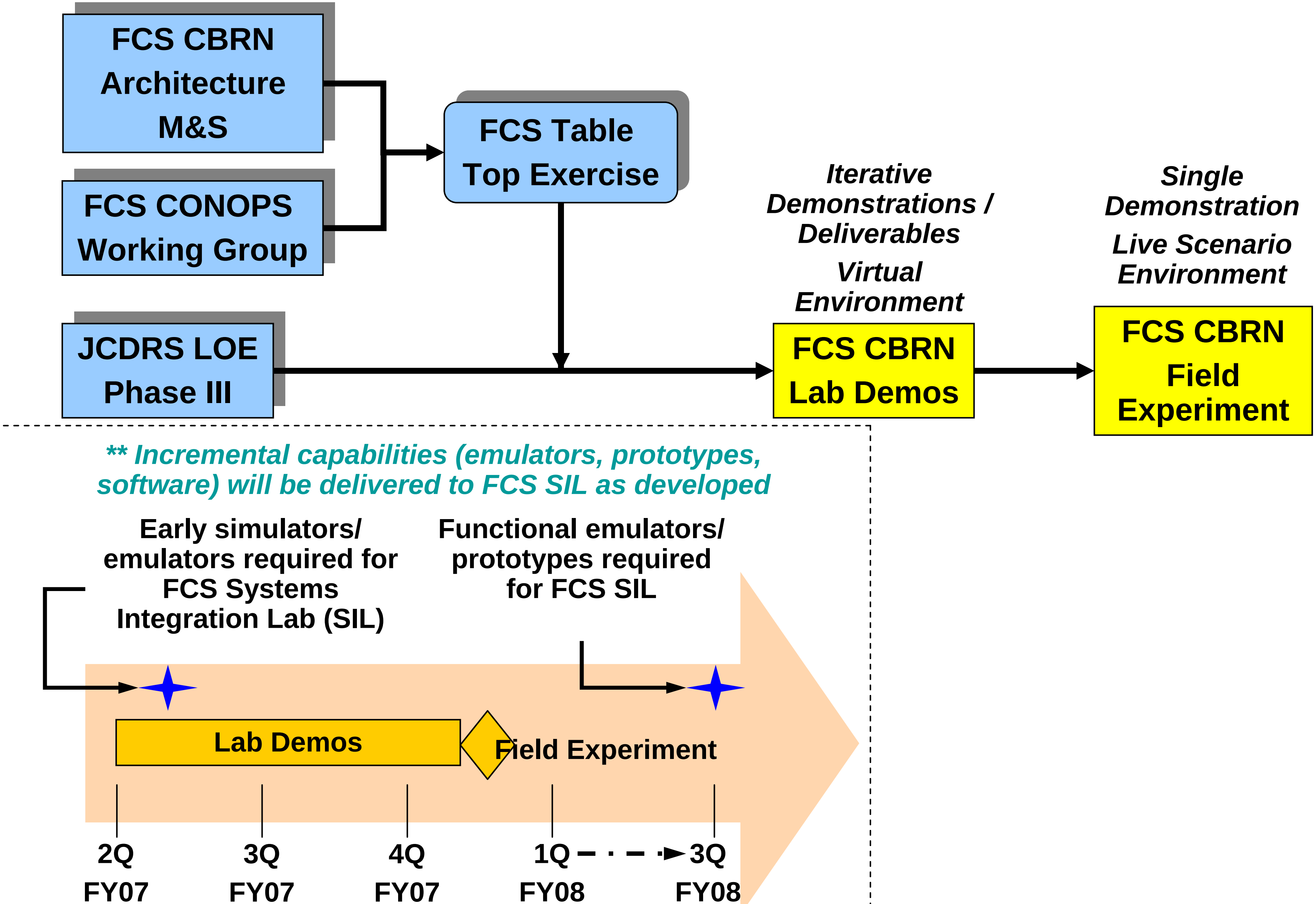
- **Access to non-CBRN data**
  - **Will architecture support this?**
  - **Radar, EO/IR, Acoustic, Seismic, X-int**
- **Algorithms to comb thru non-CBRN sensor data for CBRN signatures**
  - **Anomaly detector? Matched filters?**
  - **Where do algorithms reside? At sensor node, C2 platform?**
- **Algorithms to tip & cue CBRN sensors**
  - **What are acceptable false trigger rates?**
  - **Does CBRN sensor state change (i.e., operate at a different point on the ROC curve)?**

Implications and Development Needs (2 of 2)

- **Decision aids and COA guidance based on accumulated information**
  - Given large amounts of data/information, what degree of automation is achievable to prevent operator overload?
  - As more specific and precise information is gathered, how should the commander's response change (i.e., confidence vs. regret)?

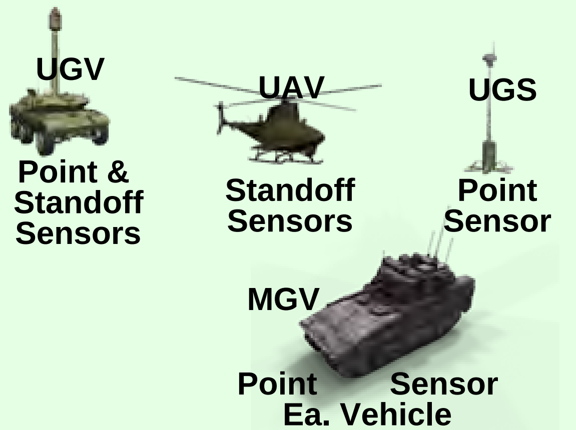
- **How to analyze and present cost/benefit to commander**
  - Given attack, cost of inaction
  - Given no attack, cost of action
  - Break points versus confidence in accumulated information

Demonstrations and Experimentation



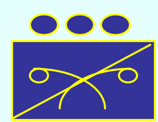
Evolution to Other Defense Systems

FCS BCT
Organic Networked Sensors



- Key FCS CBRN concepts
  - Organic, networked sensing
  - Data fusion and COP
  - Use of all BCT ISR assets
- Spin out FCS CBRN concepts to additional current and future systems
  - Naval system MDAPs
  - Army infantry and Stryker BCTs

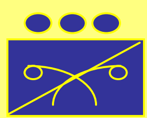
Infantry BCT
Stand Alone Sensors



Dismounted
CBRN Recon PLT
One per BCT

Point Sensor
Per PLT

Heavy & Stryker BCT
Stand Alone Sensors



Mounted CBRN Recon PLT
One per BCT

Point Sensor
Per PLT

Summary

- Information systems are key to future force success in a CBRN environment
- Success will come by leveraging inherent strengths in ISR assets, networking, computing and training
- Much remains to be done in understanding system level performance and the impact on component performance

Information Systems Science & Technology Capability Area

CBIS 2007 Brief
Mr. Charles Fromer
JSTO IS S&T CAPO
9 January 2007

Modeling & Simulation / Battlespace Joint Acquisition Responsibilities

Technology Transition Agreements

Define The Need

SHAPE
CBA Gaps

- Integrated Early Warning
- Battlespace Analysis
- Battlespace Management

Find / Build The Technology

Select, Evaluate & Manage S&T Projects

Build The System

- JWARN
- JOEF
- JEM
- T&E
- Other

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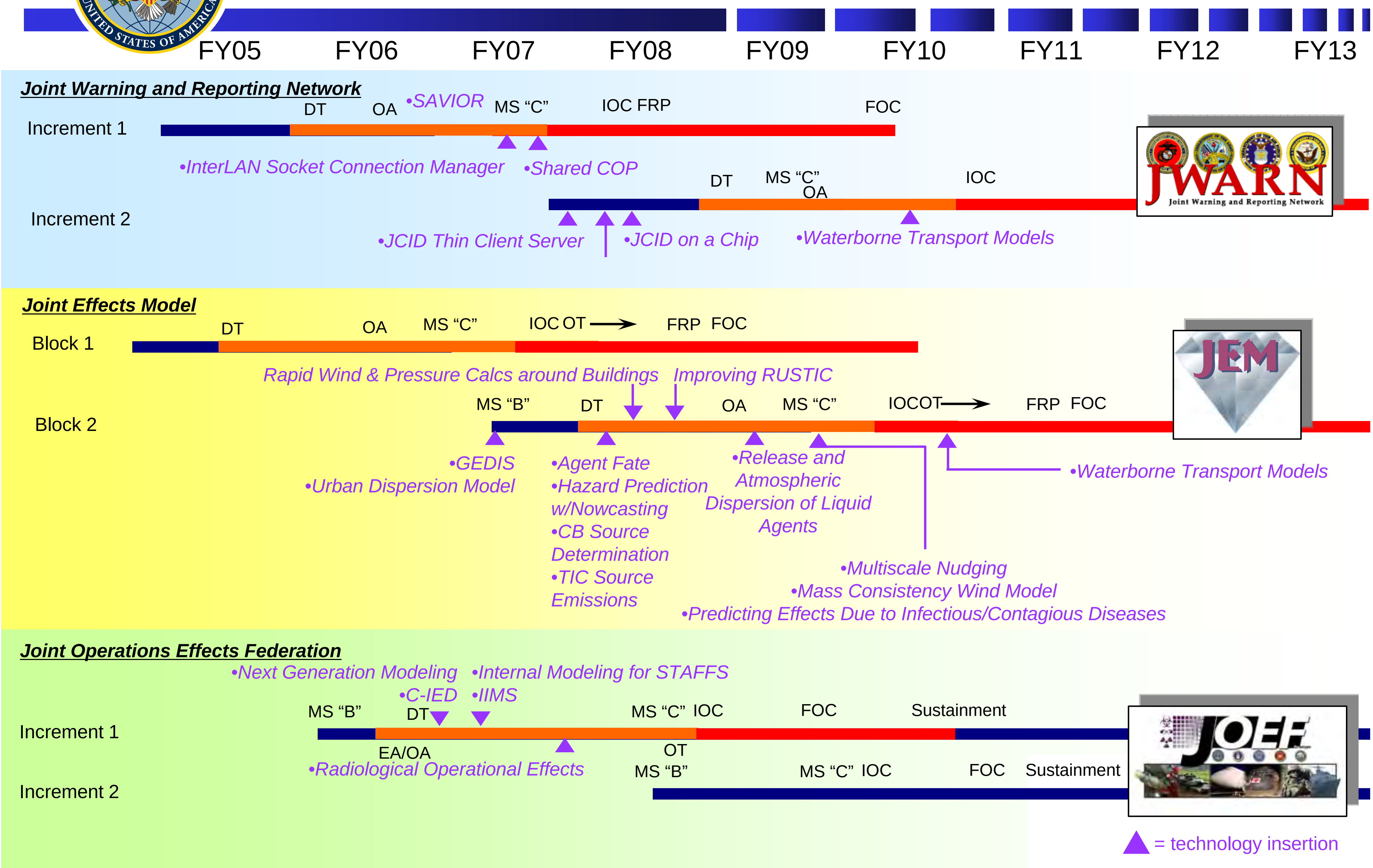
Acquisition Pull: The Technology Transition Paradigm



Acquisition Pull: The Technology Transition Paradigm

FY05 FY06 FY07 FY08 FY09 FY10 FY11 FY12 FY13

Joint Program Manager for Contamination Avoidance

JPM-CA (TBD)

CBRN Software Services

Program Director – Test Equipment Strategy and Support

PDTESS

Performance Evaluation Decon Model for T&E
Performance Evaluation Contamination Avoidance Model

Performance Evaluation COLPRO Model for T&E

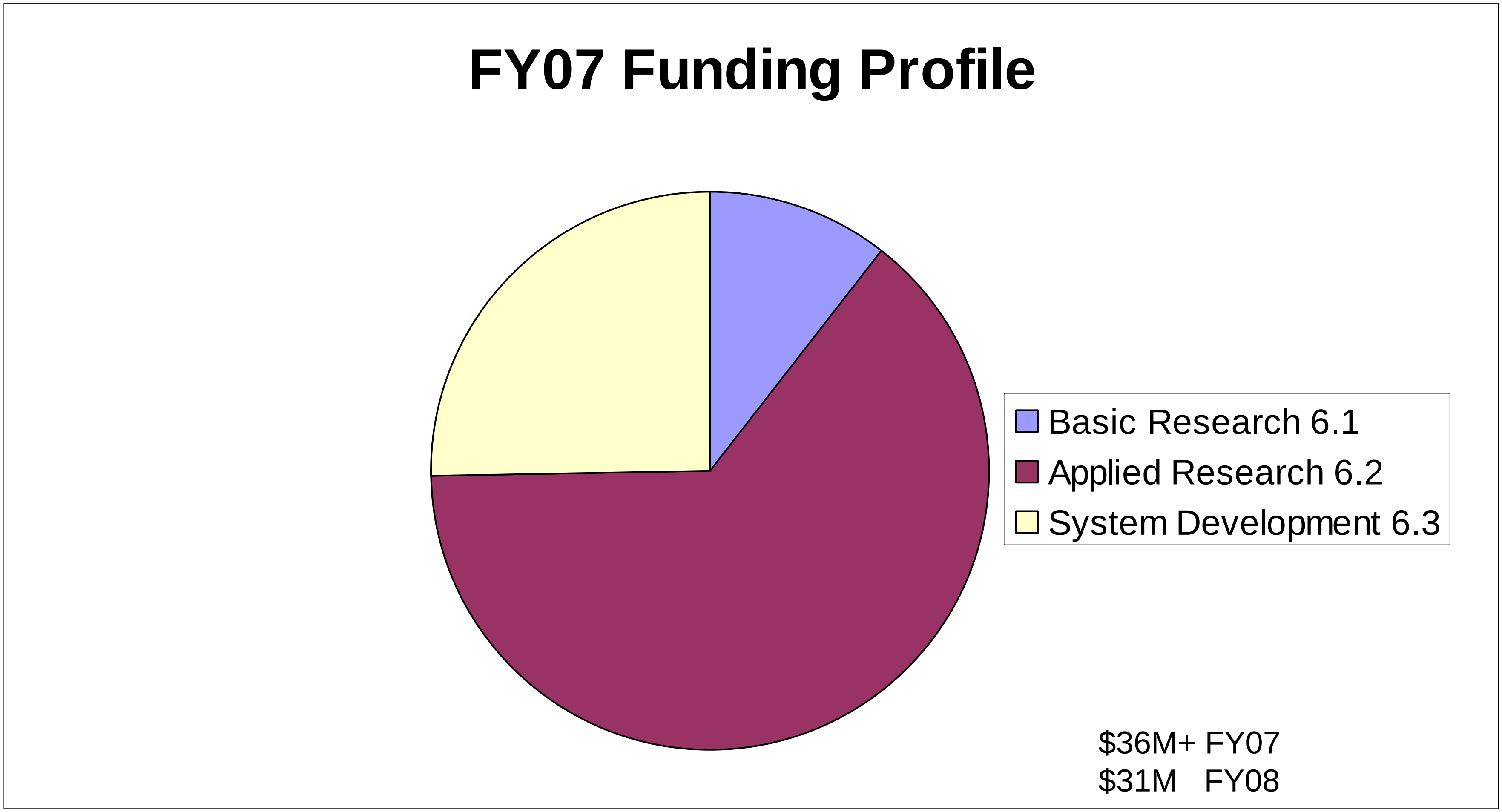
Major Defense Acquisition Programs

FCS (TBD)

CB Sim Suite

▲ = technology insertion

Information Systems S&T Funding



IS S&T Performer Base

- Aerodyne Research
- Air Force Research Laboratory, Dayton, Ohio
- Air Force Research Laboratory, Rome, New York
- Army Research Laboratory
- Applied Research Associates
- Battelle Memorial Institute
- CFD Research Corporation
- Cubic Corporation
- Defence Science & Technology Laboratory (UK)
- Defense Threat Reduction Agency
- Dugway Proving Ground
- Edgewood Chemical Biological Center
- Hanna Consultants
- Institute for Defense Analyses
- ITT Industries
- Kettering University
- Los Alamos National Laboratory
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Massachusetts Institute of Technology – Lincoln Laboratory
- Natick Soldier Center
- National Center for Atmospheric Research
- National Oceanographic and Atmospheric Administration`
- NAVOCEANO
- Naval Research Laboratory
- Naval Surface Warfare Center, Crane Division
- Naval Surface Warfare Center, Dahlgren Division
- Office of Naval Research
- Pennsylvania State University
- RDECOM
- RiskAware Ltd.
- RTI World
- SAIC
- San Jose State University
- Sandia National Laboratories
- Sentek Consulting
- Sparta, Inc.
- SPAWAR
- Titan
- TRADOC Analysis Center-White Sands Missile Range
- Tyndall Air Force Base
- University at Buffalo
- University of California, Santa Barbara
- University of New Mexico
- University of North Florida
- University of Utah

Industry - DoD Laboratories - *Academia* - *Other Government Laboratories* - *Not for Profit* - *International Partners*

New Initiatives

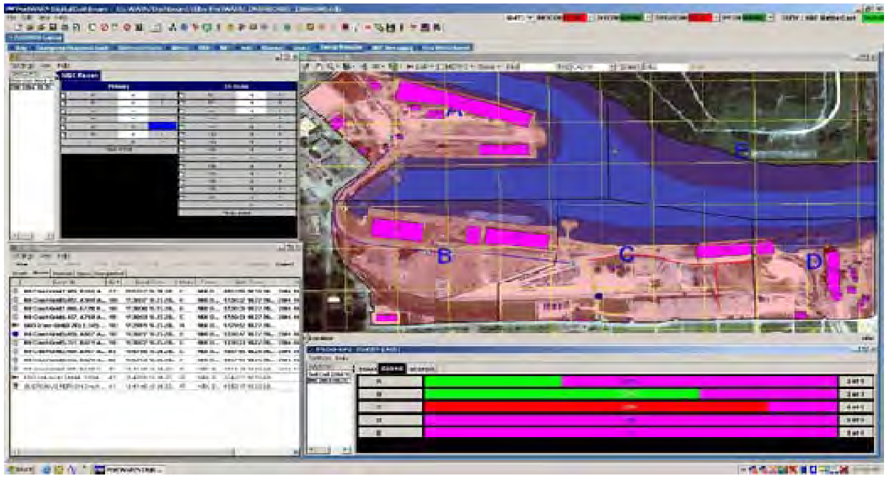
- Program is intensely focused on transitions in FY08-FY10
- Cutting edge research will begin in the following areas:
  - TCTI (Transformational Countermeasures Technology Initiative)
    - Nanotechnology
    - Biotechnology
    - Advanced Information Science
    - Cognitive Science
  - Advanced data systems to support sophisticated decision support tools

JSTO IS Taxonomy

THRUST AREAS	THRUSTS	THRUST MGRS
Network Architectures	Battlespace Management	Ginley
	S&T Data Backbone	Lowenstein
	Rapid Assimilation of Sensor Information Research (RASIR)	Hannan
	Medical Surveillance Systems	Chotani
Hazard and Environmental Modeling	Transport and Dispersion	Fry
	Environmental Science	Hamilton
Simulation, Analysis and Planning	Operations Effects	Fagan
	Decision Support S&T	Miller
	Medical Effects Modeling	Fitzgerald
Systems Performance Modeling	Test and Evaluation Performance Evaluation Models	Sears
	MDAP M&S Support	Zimmerman

CB Defense Battlespace Management Thrust Area

Objective: Develop the science behind collaborative information management technologies for insertion into the Joint Warning and Reporting Network (JWARN) acquisition program.
Description of Effort: Develop configurable battle management modules for data acquisition, sensor integration, early warning and reporting and mission impact to enhance JWARN capabilities.
Benefit to warfighter: Improves integrated early warning and provides a common operating picture (COP) for enhanced decision making.



Major goals/milestones:

Near Term (Through FY09)
- Transition COP to JOEF/JWARN
- Evaluate integration of medical syndromic surveillance

Mid Term (Through FY11)
- Develop and transition next generation technologies and net-centric enterprise integration
- Integrate SDF technologies into CB network

Far Term (FY12 & Beyond)
- High speed data acquisition supporting full spectrum decision support for CB

FY07 Projects:

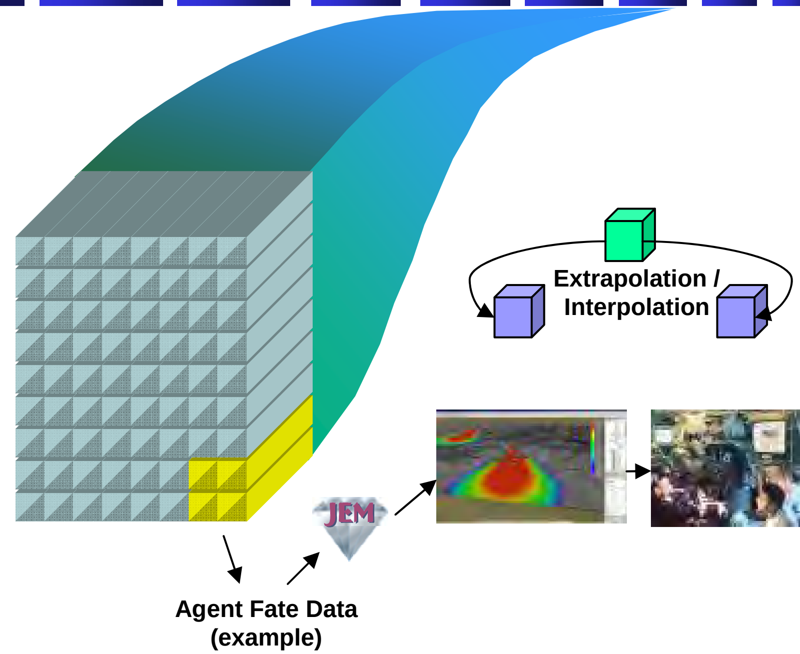
BA05MSB005	Shared Common Operating Picture (COP) for HLS and HLD
BA06MSB102	Inter-LAN Socket Connection Manager (ILSCM)
CO06MSB005	JCID on a Chip
BA07MSB129	Information Interoperability for CBD Battlespace Management
BB06MSB044	Common CBRN Software Services
BA06MSB024	Sensor Alert Verification for Incident Operational Response (SAVIOR)
BB06MSB041	JCID Compliant Thin Server for Sensors
	LG7/ATP-45

CB Validated Interactive Science & Technology Data Backbone

Objective: Fill critical data gaps in the areas of basic science which support the CB Defense Program, & develop a web-based system for storage & access of this CB M&S & IT development data & knowledge.

Description of Effort:
Develop Data Backbone Tables (e.g., Bio agents, Chem agents, TICs/TIMs, Simulants, Substrates, Background materials). Candidate Data Fields/Attributes include Genomics, Proteomics, Persistence, Exposure risks, Signatures, Environmental variables, Dose rate, Vapor pressure, Spectral signature

Benefit to warfighter: The CBD M&S and IT tools that are being planned or developed are critically dependent on data and meta-data in a broad range of areas, including, for example, data describing fundamental physical, biological or chemical science, as well as human medical effects. Data of this kind is critical to the development and operation of these tools, so that its non-availability represents a significant risk to system development/acquisition. However, while data of this kind is of clear interest to M&S and IT system developers, it is of equal or greater importance to operational users (warfighters).



Major goals/milestones:

Near Term (FY06 – FY08)
- Determine scope of effort, begin to identify data structure
- Determine method for Permanently Capturing Data

Mid Term (FY09 – FY11)
- Gather data and populate backbone
- Determine data to be collected and areas of future research

Far Term (FY12 & Beyond)
- Use data for Experimentation and Training, Test and Evaluation, Model Development

Responds to a need pointed out by the General Accounting Office (GAO), in its report dated April 28, 2006:

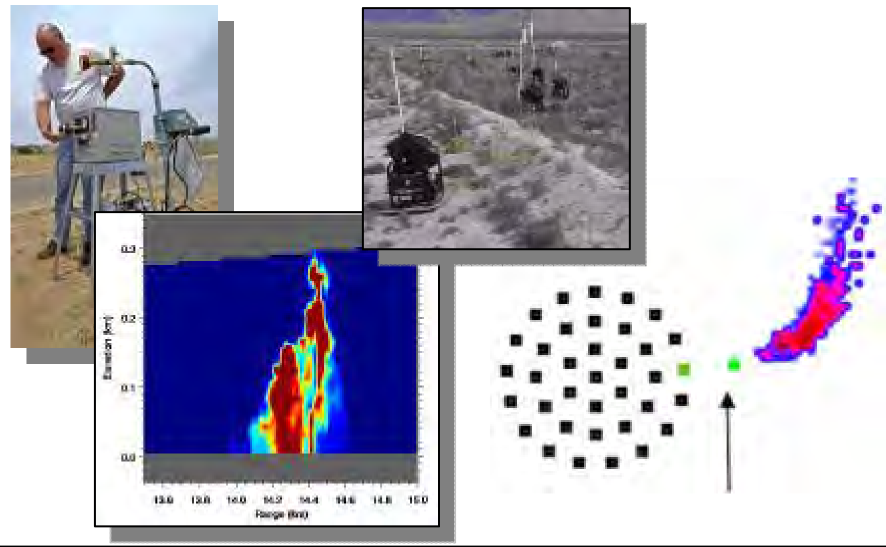
"…develop a centralized database with information about the effects of chemical and biological agents on materials used in weapon systems." This will minimize the risk of unnecessary expenditures on duplicative testing, as well as increase the effectiveness of CB models.

Rapid Assimilation of Sensor Information Research (RASIR)

Objective: Develop scientific techniques for fusing disparate information from multiple sources as part of a technology "push" effort for JEM, JOEF, and JWARN, as well as other identified acquisition programs of record.

Description of Effort: Develop methods to fuse CB sensor information, local meteorology, and environmental data with transport & dispersion (T&D) algorithms for the purpose of source term characterization, hazard prediction refinement, and optimization of sensor networks. This will enhance the capabilities of JEM, JOEF, and JWARN.

Benefit to warfighter: Improves battlespace awareness by identifying source location and movement of environmental hazards through fusing all available information into a well-ordered, manageable system for decision makers.

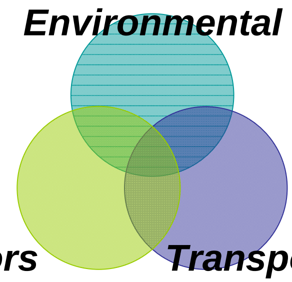


Major goals/milestones:

Near Term (Through FY09)
- Inauguration of SDF-related technologies
- Conduct field trial for V&V of developmental SDF algorithms

Mid Term (Through FY11)
- Transition validated source determination tool
- Transition validated hazard refinement capability
- Transition validated sensor placement tool

Far Term (FY12 & Beyond)
- Develop capability to continuously refine and update contamination footprint through assimilation of limited and disparate information into meteorological and T&D models.



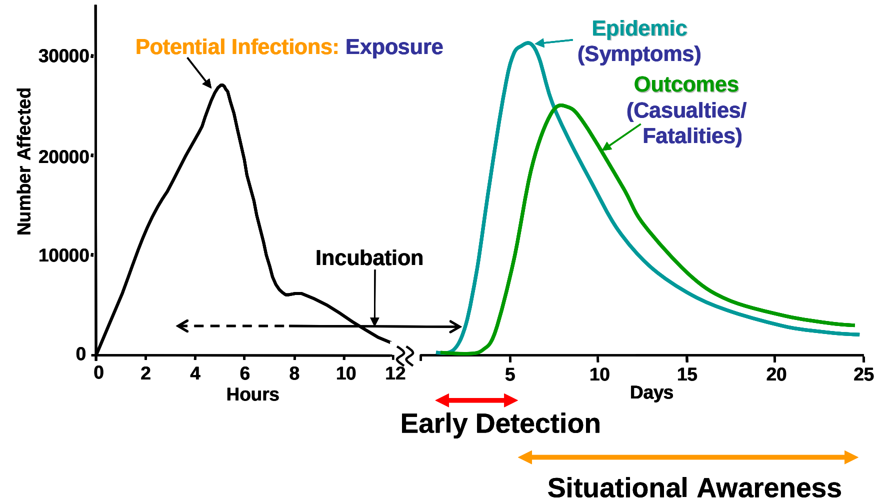
JWARN Joint Warning and Reporting Network

JEM

JOEF

Medical Surveillance Systems Thrust Area

Objective: Combine modeling & simulation, medical surveillance, early warning detection and real-time epidemiology to develop technologies and models that can identify anomalies related to infectious diseases in warfighter (and civilian populations if data is available) in-theater using bio-surveillance and early detection models.
Description of Effort: Embark on novel technologies as well as evaluate, validate, support and assist in integration of existing initiatives.
Benefit to warfighter: Minimize warfighter casualty due to infectious diseases, in particular biological WMDs.



Major goals/milestones:
Near Term (Through FY09)
- Provide a well-founded model for casualty estimates in JEM involving infectious/contagious diseases, both bioagent-induced and naturally occurring.

Mid Term (Through FY11)
- Provide models for syndromic surveillance, disease epidemiology, casualty estimation, and prediction of human performance in hazard environments.
- Furnish capability to model infectious/contagious diseases, both bioagent-induced and naturally occurring.
- Provide capability of casualty estimation (morbidity & mortality) due to CBR agents.

Far Term (FY12 & Beyond)
- Provide capability to rapidly and accurately (high sensitivity & specificity) model infectious/contagious diseases, both bioagent-induced and naturally occurring.
- Provide comprehensive medical test and evaluation model.

FY07 Projects:

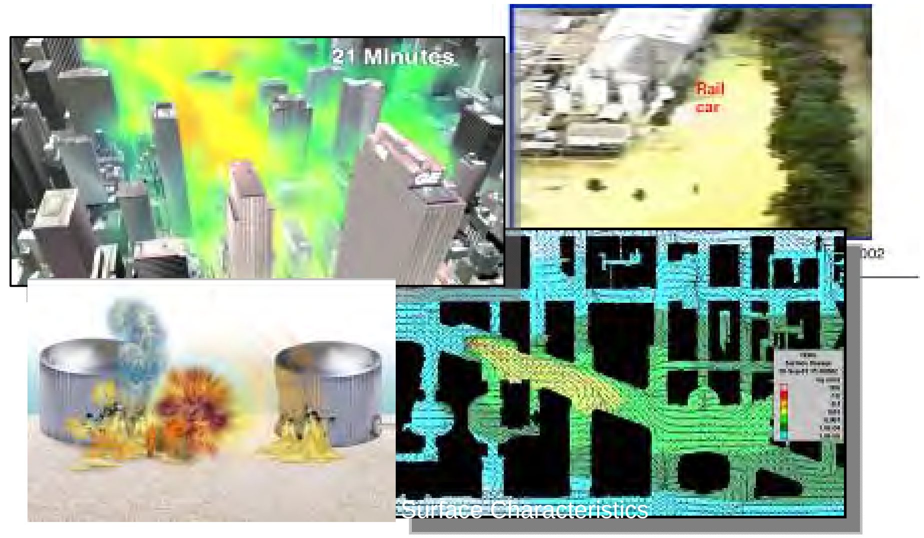
BO07MSB001	Comparison of Existing Medical Surveillance Models
BO07MSB002	Infectious Disease Analysis Capability (IDAC)
CB07MSB100	Predicting Effects Due to Infectious/Contagious Diseases for JEM

CB Advanced Transport and Dispersion Modeling Thrust Area

Objective: Improve battlespace awareness by accurately predicting hazardous material releases and their atmospheric transport and dispersion (T&D). CB Sources, Urban and terrain effects and building interiors are modeled.

Description of Effort: Develop methods and tools incorporating Geospatial data (terrain/urban) and toxic industrial chemical models for dense gas, two-phase flow and pressurized liquids.

Benefit to warfighter: Improves battlespace awareness by integrating T&D with Geospatial data and developing source models to enhance the capabilities of acquisition programs of record.



Major goals/milestones:

Near Term (Through FY09)

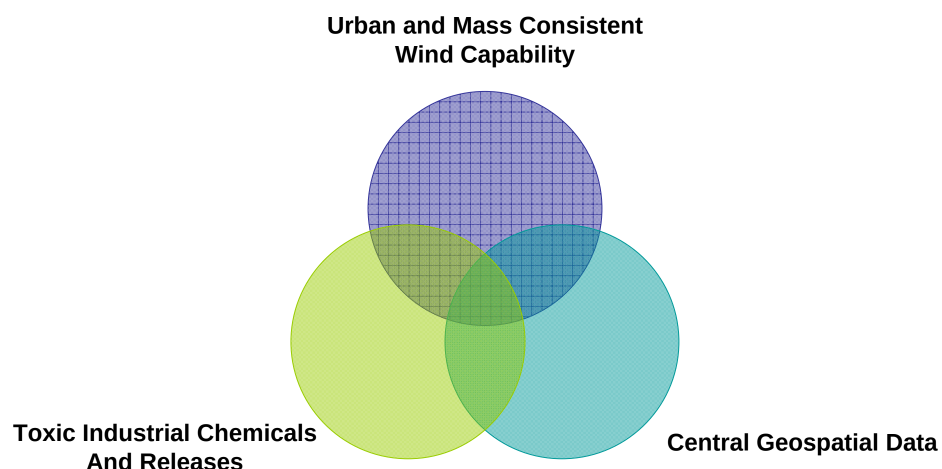
- **Improve Geospatial information interface and toxic industrial chemical and release models and atmospheric chemistry.**

Mid Term (Through FY11)

- **Centralized Geospatial data interface. Incorporate building interior dispersion.**

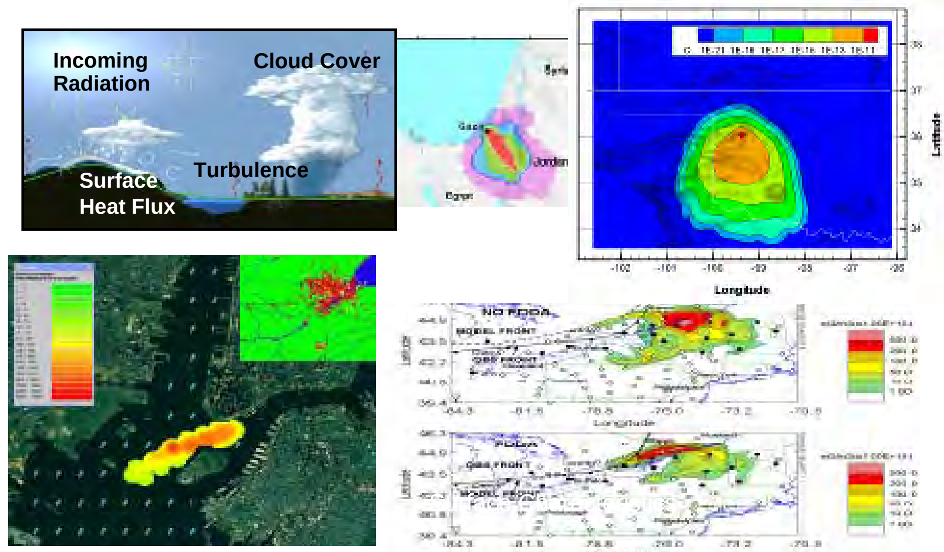
Far Term (FY12 & Beyond)

- **Capability to rapidly and accurately model T&D at high resolution in a multitude of environments.**



CB Environmental Sciences Thrust Area

Objective: To provide environmental databases and modeling capabilities in order to accurately depict and predict the state of the environment through the use of data assimilation and ensemble methods.
Description of Effort: Develop algorithms and tools to predict T&D for all potential environments including high altitude, urban, coastal, complex terrain, and waterborne domains. Integrate T&D applications with meteorological and other environmental information to enhance chem/bio acquisition programs of record.
Benefit to warfighter: Improves battlespace awareness by accurately representing the environment and quantifying the uncertainty due to the release of hazardous substances.



Major goals/milestones:

Near Term (Through FY09)
- Update climatology, terrain, and population databases
- Improve atmospheric boundary layer modeling
- Initial waterborne transport capability

Mid Term (Through FY11)
- Initial high altitude modeling capability in JEM
- Comprehensive Secondary Effects Module transitioned
- T&D modeling uncertainty quantification

Far Term (FY12 & Beyond)
- Capability to rapidly and accurately model T&D at high-resolution and in a multitude of environments. Coupled meteorological, T&D and CB modeling capability for hazard prediction.

Environmental Databases

Terrain
Landuse
Population
Climatology

→ Hazard Environment Prediction Integration ←

Meteorology & Oceanography

Modeling
Uncertainty
Assimilation

↓

JWARN Joint Warning and Reporting Network — JEM — JOEF

CB Warfare Effects on Operations Thrust Area

Objective: Develop the science behind the modeling and simulation of operations in a CB environment at fixed facilities as well as mobile operations for insertion into the Joint Operational Effects Federation (JOEF) acquisition program.

Description of Effort: Develop the tools and modules for modeling operations of airfields, ports, depots, combat units and support personnel, e.g. medical and logistics, for planning and vulnerability analysis in a CB environment to enhance JOEF capabilities. Provide the Combatant Commanders the ability in a CBRNE attack, near real-time Alternative Course of Actions for tactical planning, crisis response, medical/non-medical consequence management with associate probabilities of success and impacts to operations/mission. Asymmetrical warfare and non-conventional weapons responses during full spectrum warfare and peacekeeping/nation building.

Benefit to warfighter: Improves battlespace management by providing tools in which decision makers plan, simulate and execute operations.

Major goals/milestones:

Near Term (Through FY09)

- **APOD impact model transition to JOEF**
- **CBR effects integrated into selected tactical maneuver model**
- **Integrate capabilities from Consequence Assessment Tool Set (CATS) into JOEF**

Mid Term (Through FY11)

- **CBR effects integrated into theater and campaign-level models/simulations**

Far Term (FY12 & Beyond)

- **Federate fully integrated with data backbone**

FY07 Projects:

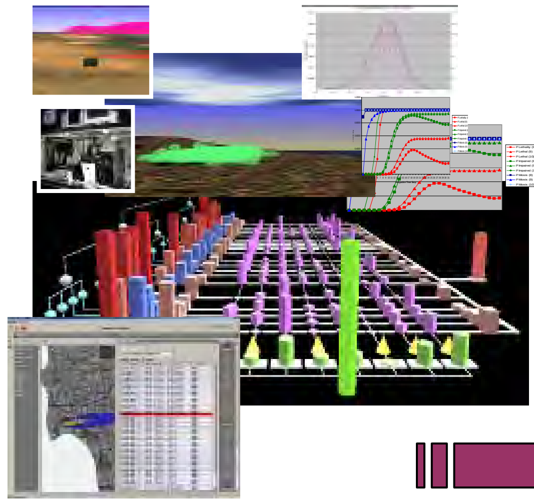
BA05MSB030	CB System Military Worth Assessment Toolkit
BA05MSB052	Next Generation Model of CB Effects on Military Operations
BA06MSB016	Internal Modeling Capability for STAFFS
BA06MSB025	Rapid Mission Impact Assessment Tool
CA06MSB090	Improvements in Chemical, Biological and Radiological (CBR) Operational Effects Modeling Tools and Methods
BB06MSB051	Automated CBRN Data Import/Export Tool
BB05MSB011	CB Effects on Operations: Impact Assessment Tool
BB06MSB017	CBRN in Tactical and Theatre Level Simulation
BB06MSB021	IMPACT Framework

CBDP Decision Support Tools & Methodologies Thrust Area

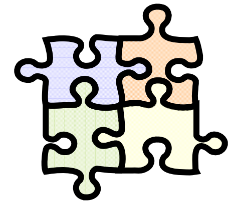
Objective: Develop the science behind tools for decision making and human knowledge management across the CB Defense Program. These tools will be maintained as part of JSTO's full suite of capabilities.

Description of Effort: Develop the tools and modules for investment/portfolio decision support, virtual prototyping, knowledge management and emerging technology exploration for inclusion into the JSTO program.

Benefit to warfighter: Improves the quality of the products, technologies and capabilities supplied to the warfighter at a reasonable cost.



Improved RDA Process



Community data resources

Major goals/milestones:

Near Term (Through FY09):

- Develop decision support tools for CB investment portfolio.
- Identify revolutionary technologies and opportunities in data backbone efforts.

Mid Term (Through FY11):

- Fully assess virtual prototyping capabilities, provide full support to efforts focusing on revolutionary concepts.
- Determine data to be collected and areas of future research.

Far Term (Through FY15):

- Become fully immersed in CB virtual environment to support test and training.
- High speed data acquisition supporting full spectrum decision support for CB.

FY07 Projects:

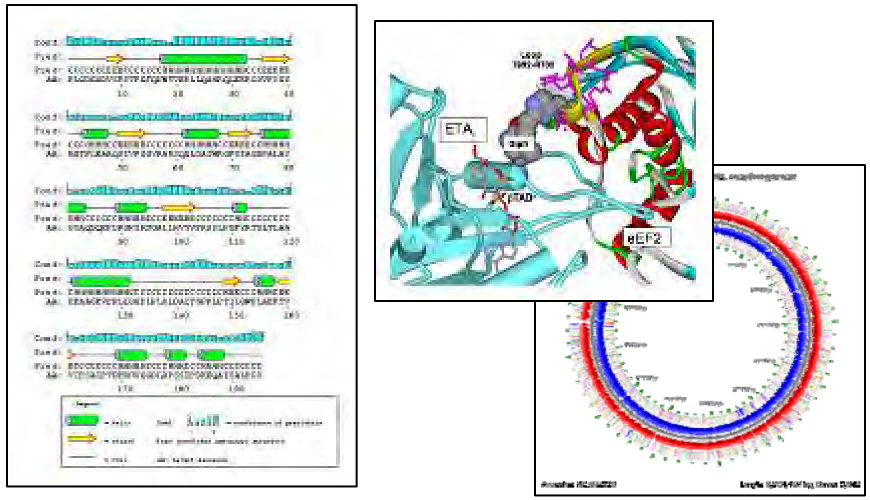
BA05MSB062	Analytic Capabilities Development
BO05MSB070	Multivariate Decision Support Tool for CB Defense
CA06MSB037	CB Simulation Suite
BA05MSB030	CB System Military Worth Toolkit
BA07MSB087	Investment Planning and Analysis Tool

Medical Effects Modeling Thrust Area

Objective: Provide models for syndromic surveillance, disease epidemiology, casualty estimation, and prediction of human performance in hazard environments.

Description of Effort: Develop the tools and modules to provide syndromic surveillance, disease epidemiology, casualty estimation, and prediction of human performance in hazard environments for the Joint Operational Effects Federation (JOEF).

Benefit to warfighter: Provide increased awareness of medical impacts on warfighters to decision makers to allow for informed planning.



Major goals/milestones:

Near Term (FY07 – FY09)
- Transition NBC Crest to JOEF
- Medical Automation and Support Tools

Mid Term (FY09 – FY11)
- Provide models for syndromic surveillance, disease epidemiology, casualty estimation, and prediction of human performance in hazard environments

Far Term (FY12 & Beyond)
- Investigate genomic and proteomic modeling within the human body in order to investigate agent pathology
- Perform modeling to enable predictive pharmacology and toxicology for therapeutic purposes

FY07 Projects:

CB06MSB095	NBC CREST Transition to JPM-IS
CB06MSB096	Medical Modeling of Particle Size Effects for Inhalation Hazards
CB07MSB100	Predicting Effects Due to Infectious/Contagious Diseases for JEM

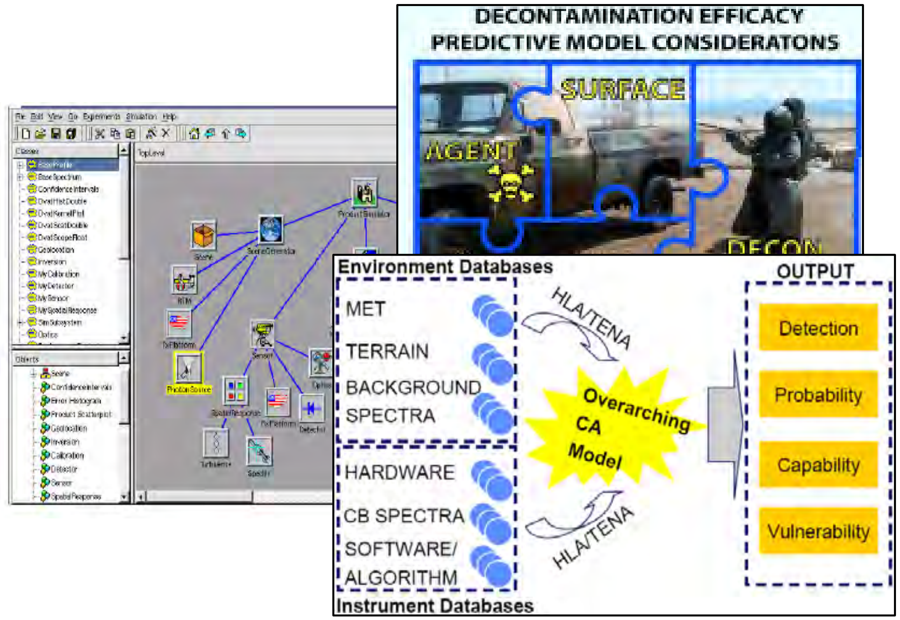
CB Test & Evaluation (T&E) Modeling & Simulation Thrust Area

Objective: Develop the science behind the modeling and simulation tools that assist the T&E community in evaluating CB technologies.

Description of Effort: Develop an integrated CBD toolkit for the test and evaluation of emerging CBD commodities, compatible with all IS programs of record. The toolkit will:

- Support product test and evaluation in light of other CBD products' performance and capabilities,
- Integrate Commodity Area Models in ColPro, IP, CA, and Decon into one toolkit with information passing smoothly between individual commodity models,
- Seamlessly integrate output from JEM regarding agent dispersion and deposition and JWARN NBC detector/sensor data,
- Provide performance information to JOEF and/or the Unit Mission Testing Model, and
- Enable rapid insertion of product test data as it becomes available, from any accredited source, for up-to-date, enhanced commodity models

Benefit to warfighter: Support quality developmental and operational testing of JPEO end items.



Major goals/milestones:

Near Term (Through FY09)

- **Development of commodity area models**

Mid Term (Through FY11)

- **Continue development and transition of T&E models**

Far Term (FY12 & Beyond)

- **Development of comprehensive medical T&E model**

FY07 Projects:

CA06MSB414	Overarching Contamination Avoidance Model for Test and Evaluation
CA06MSB424	CREATIVE Decontamination Efficacy Prediction Model
CA06MSB427	Overarching Collective Protection (COLPRO) Model for Test and Evaluation
	Overarching Individual Protection (IP) Model Feasibility Study

Customers:

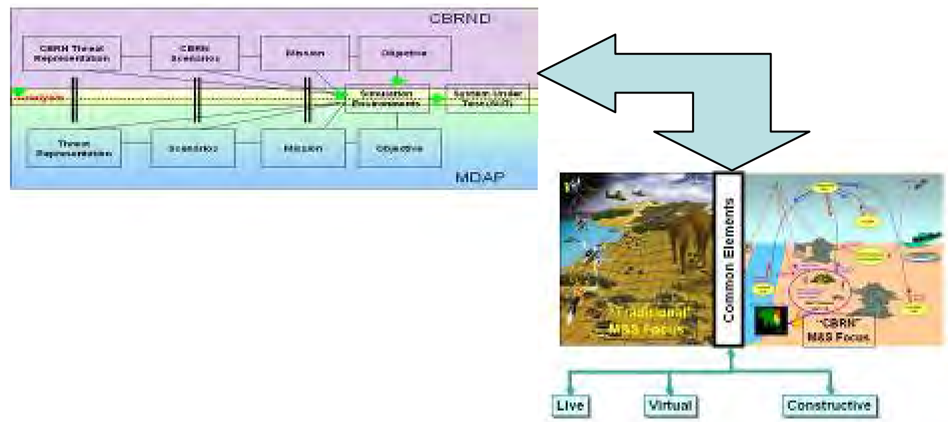
MDAP M&S S&T Thrust Area

Objective: To develop and transition supporting CB M&S for MDAP, and acquisition programs using M&S or M&S programs developing capabilities in support of acquisition.

Description of Effort: Develop the supporting tools and techniques needed to integrate CBRN M&S capabilities to acquisition programs (e.g., Future Combat Systems) using M&S or M&S programs. The scope of this thrust area is in support of acquisition programs that have a CB survivability requirement or KPP.

Benefit to warfighter: Provide coherent CB representation to acquisition programs using M&S or M&S programs

Approach:



Near-Term Projects:

- Near Term (FY07 – FY08)
  - •Transition of CB Sim-Suite to OOS
  - •Participate with Simulation Interoperability Standards Organization Study Group on Live, Virtual, Constructive Architecture Interoperability
  - •Coordination with JPEO CBD Future Systems Team

Challenges:

- Interoperability between CBR M&S and non-CBR M&S
  - •Challenge lies in performance, validation, and "fidelity"

Potential Project Areas:

- MDAP Areas
  - •Future Combat Systems (FCS)
  - •Expeditionary Fighting Vehicle
  - •Littoral Combat Ship (LCS)
  - •DD(X)
  - •Amphibious Assault Ship (LHA(R))
  - •Aircraft Carrier (CVN21)
  - •Joint High Speed Vehicle (JHSV)
  - •Joint Maritime Assault Connector (JMAC)
  - •Maritime Pre-positioning Force (Future)
  - •Joint Strike Fighter (JSF)
  - •Theater High Altitude Defense (THAAD)
  - •Comprehensive Force Protection Initiative (CFPI)

IS S&T Basic Science

Technology Push:

- Centralize investment in basic research (6.1)
- Identify and exploit technology opportunities
- Identify and respond to new and emerging threats
- Maintain a robust technology base: knowledge, research capabilities, and test and evaluation methodologies

FY07 Projects:

AO06MSB001	Relationship of Boundary Layer Winds to Soil Moisture & Cloud Properties
AO06MSB002	Link Equations of Motion for Terrestrial and Space Environments
AO06MSB003	Blending CB Dispersion Forecasts and Sensor Data
AO06MSB004	Turbulence in the Stable Boundary Layer

Effectiveness of Urban Shelter-In-Place (SIP): What factors affect effectiveness

Dr. Ashok Gadgil

Research colleagues: W. Chan, P. N. Price, and W. W. Nazaroff

Lawrence Berkeley National Laboratory

http://buildingairflow.lbl.gov

CBIS Conference, Austin, TX, January 8-11, 2007

Research supported by Dept. of Homeland Security, R&D Directorate

Outline

- Introduction
- Idealized models for analysis
- Metrics of effectiveness for community SIP
- Results from idealized models
- Conclusions

Background

- **Catastrophic outdoor toxic chemical releases**
  - Often sudden and unanticipated (~100 per year in the U.S. requiring community decisions and public responses)
  - For a dense large community, evacuation is often infeasible
- **Shelter-in-Place (SIP)**
  - Could be an effective temporary measure
  - Has been documented to have provided successful protection

Introduction

- **Many factors can affect SIP effectiveness**
  - Studies on SIP effectiveness for individual buildings exist
  - However, what about effectiveness of SIP for a whole community?
  - What is the relative importance of building air-exchange rates, toxic load exponent? Duration of release? Delays in starting and ending SIP?
  - How do these factors interact in influencing the effectiveness of SIP for a community?

Approach

- **Start with an idealized representation of the problem -- so as to remove event-specific particularities**
  - Some simplifications are made to abstract general conclusions

Models

Three Simple Models Interact to quantify Community-SIP:

- **An Outdoor Plume model**

- **A model to predict Indoor Concentrations**

- **A model to predict Health Effects**

Simplifications

- **The plume is modeled as Gaussian with constant steady wind**
- **Toxic chemical in the plume is idealized**
  - it is conserved, and does not sorb/desorb on indoor surfaces
- **Population density is uniform**
  - This provides predictions clear of complications from density variations
- **All community members respond promptly to SIP instructions**
  - all start SIP at t=0, and all end it together when told
- **Indoor Concentration are predicted with a well-mixed box-model**
- **Community houses have uniform air exchange rate**
  - We do explore different values of this parameter

Outdoor Plume Model

a variant of the Gaussian atmospheric diffusion model

$$C_{out}(x,y,z,t) = C_G(x,y,z)\cdot\frac{1}{2}\left[erf\left(\frac{x}{\sigma_x\sqrt{2}}\right) - erf\left(\frac{x-\overline{U}t}{\sigma_x\sqrt{2}}\right)\right] \quad \text{for} \quad t \le T_r$$

$$C_{out}(x,y,z,t) = C_G(x,y,z)\cdot\frac{1}{2}\left[erf\left(\frac{x-\overline{U}(t-T_r)}{\sigma_x\sqrt{2}}\right) - erf\left(\frac{x-\overline{U}t}{\sigma_x\sqrt{2}}\right)\right] \quad \text{for} \quad t \ge T_r$$

Outdoor Plume Model specifics

the Gaussian atmospheric diffusion model:

- Assumes a Steady wind speed and direction
- Uses dispersion coefficients based on curve fits to the standard Pasquill-Gifford data
- Employs a uniform grid (results checked for grid-independence)
- Uses a No-flux boundary at the ground and the mixing height using image-sources
- Assumes release at the ground level
- Predicts concentrations at a height of 2m above ground for the indoor model

Indoor Concentration Model

a well-mixed box model for indoor concentrations:

$$\frac{dC_{in}(x,y,t)}{dt} = \frac{Q}{V} \cdot \left[C_{out}(x,y,t) - C_{in}(x,y,t)\right]$$

- Sorption and desorption on indoor surfaces is ignored
- Similarly, filtration by the building envelope is ignored
- Mass balance is used to calculate indoor concentrations at each grid cell
- Indoor concentrations are updated at one minute intervals

Health Effects Model

a toxic-load model for health-effects:

$$\mathrm{TL}(t) = \int_0^t \left(C(t')\right)^m dt'$$

- For some chemicals, exposure to high concentrations for short duration is much worse than exposure to low concentrations for long durations. The effect is non-linear
- This behavior is incorporated into a toxic-load model (ten Berge 1986)
- We calculate the (time-dependent) toxic-load for each grid-point for both indoor and outdoor conditions
- When a present Toxic Load Limit ("TLL") is exceeded, corresponding adverse health effect is deemed to have taken place. We use the AEGL limits (NRC 2003) in our simulations

Community-SIP effectiveness

- Measuring community SIP effectiveness is complex
- Existing metrics in the literature relate to SIP protection from individual buildings
- Existing metrics for SIP effectiveness ignore the non-linear health-effects of many toxic chemicals
- We developed two new metrics relevant to this study: explained in the next slides

Summary of the two metrics

- **Casualty Reduction Factor measures how many fewer casualties occur indoors (with SIP) versus outdoors (without SIP)**

Causalty reduction factor = CRF

- **However, in some releases, there are no casualties even outdoors. SIP still improves the factor of safety in such cases. Safety Factor Multiplier measures the increase in the safety factor resulting from SIP**

Safety Factor Multiplier = SFM

First Metric of Community-SIP: CRF

Casualty Reduction Factor (CRF)

$$\text{CRF} = 1 - \frac{\text{Population}\,(\text{TL}_{\text{indoors}} > \text{TLL})}{\text{Population}\,(\text{TL}_{\text{outdoors}} > \text{TLL})}$$

- **Equals the *fraction* of population that would avoid potential adverse health effect by sheltering indoors (compared to exposure outdoors)**

- **The numerator and denominator are the sizes of populations that would exceed the TTL if exposed to indoor and outdoor concentrations, respectively.**

More on CRF

$$CRF = 1 - \frac{\text{Population}\,(TL_{\text{indoors}} > TLL)}{\text{Population}\,(TL_{\text{outdoors}} > TLL)}$$

- Can vary from zero (no protection), to one (perfect protection)
- Can be evaluated as a function of time
- (For minor releases, CRF may be undefined because no one would be hurt outdoors, so the denominator is zero)

Second Metric of Community-SIP: SFM

Safety Factor Multiplier (SFM)

- **Safety Factor** is the multiplier by which the exposed concentrations can be increased without exceeding the TTL, the limit for adverse health effects

$$\int_0^t \left(\mathrm{SF} \cdot C(t')\right)^m dt' = \mathrm{TLL}$$

$$\mathrm{SF} = \left(\frac{\mathrm{TLL}}{\mathrm{TL}(t)}\right)^{\frac{1}{m}}$$

From Safety Factor to SFM

- Sheltering indoors can increase the safety factor. This increase is captured in the **Safety Factor Multiplier**

$$SF_{in} = SFM \cdot SF_{out}$$

$$SFM = \left(\frac{TL_{out}}{TL_{in}} \right)^{\frac{1}{m}}$$

- SFM is evaluated for each location in the plume by comparing indoor and outdoor toxic loads

- A high SFM implies effective protection with SIP. An SFM close to 1 implies SIP is ineffective -- as bad as being exposed outdoors

More on SFM

$$SF_{in} = SFM \cdot SF_{out}$$

$$SFM = \left(\frac{TL_{out}}{TL_{in}} \right)^{\frac{1}{m}}$$

- In a given event, SFM will be the same for all buildings only if they all experience the same outdoor concentration profile, and have the same air exchange rate

- Neither of these conditions apply, so a distribution of SFM values will occur in a building stock in a community exposed to a toxic chemical plume

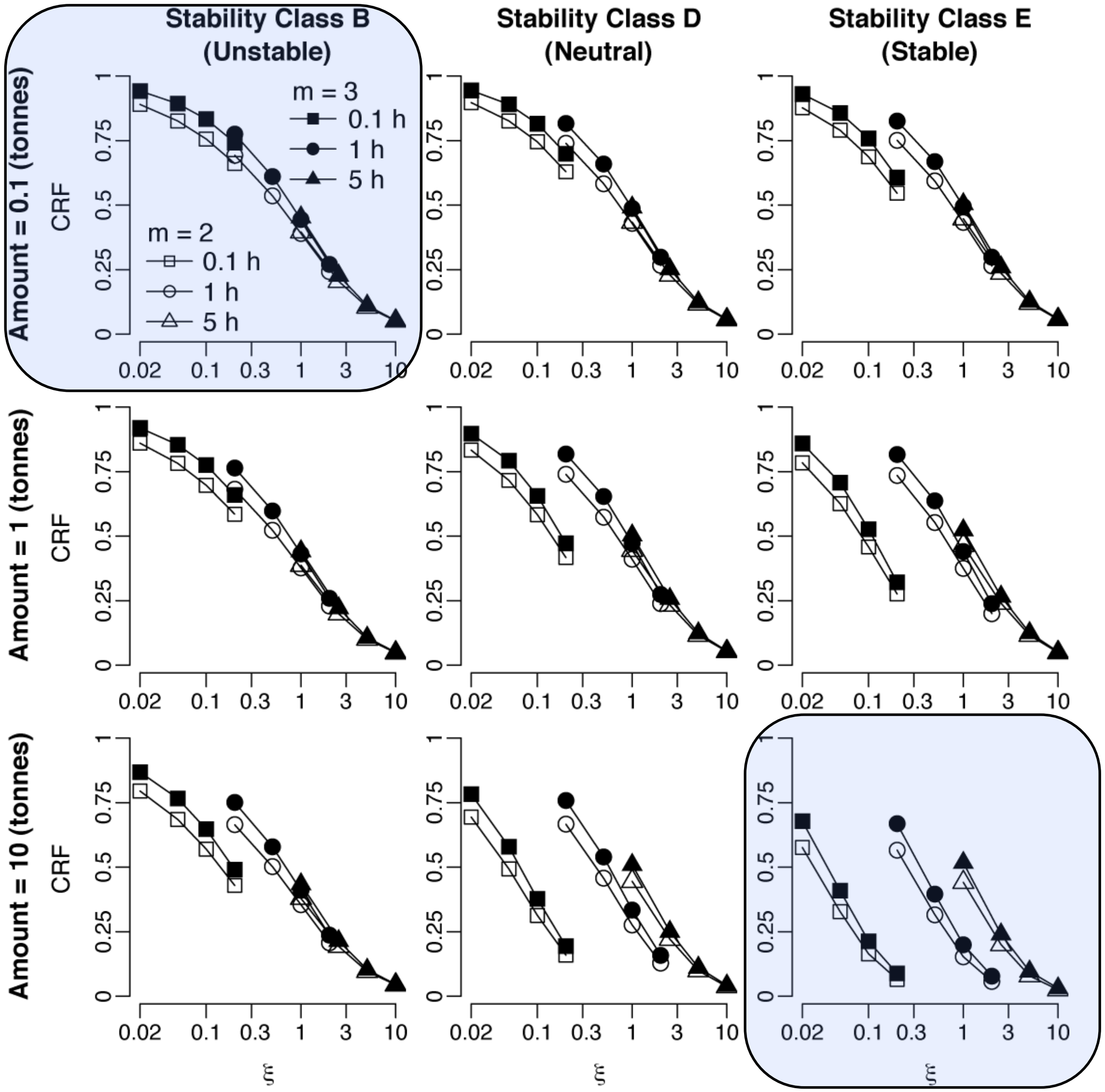
Specific Goals

Evaluate Community SIP effectiveness in terms of the two metrics (CRF and SFM) for a variety of parameter values for:

- **Release characteristics**
  - ➢ Release amounts (0.1, 1 and 10 tonnes)
  - ➢ Release duration (0.1, 1 and 5 hours)
  - ➢ Three stability classes: from B (moderately unstable), to E (moderately stable)
- **Chemical toxic load exponents**
  - ➢ Assume moderate toxicity: TLL set to 1 mg/m^-3 for 1 h (about six times less toxic than methyl isocyanate)
  - ➢ Three toxic load exponents, 1, 2 and 3
- **SIP strategy**
  - ➢ All homes have air exchange rates of 0.2, 0.5, 1, or 2 per hour (reflecting full anticipation or no anticipation and open windows)
  - ➢ SIP assumed to start immediately at start of release, at t=0
  - ➢ SIP termination explored for delays of 0.5, 1 and 3 h beyond departure of the plume

Results 1: effect of Release Duration on CRF

- **ξ, the product of air-exchange-rate and release-duration, strongly influences SIP effectiveness**
  - For m=2 and m=3, and small releases, low **ξ** leads to large CRF, I.e., high protection from SIP
  - However for m=1, for large releases, and stable atmospheric conditions (results not shown here), **ξ** does not have high explanatory power



Results 2: effect of Release Amount

- **Release-amount and release-duration interact in their effect on the CRF**

    - For releases of short duration, SIP effectiveness is highly sensitive to release amount. This is because small release will cause harm outdoors but not indoors, leading to high CRF. Also a very large release will cause harm indoors as well as outdoors in most places, leading to low CRF.

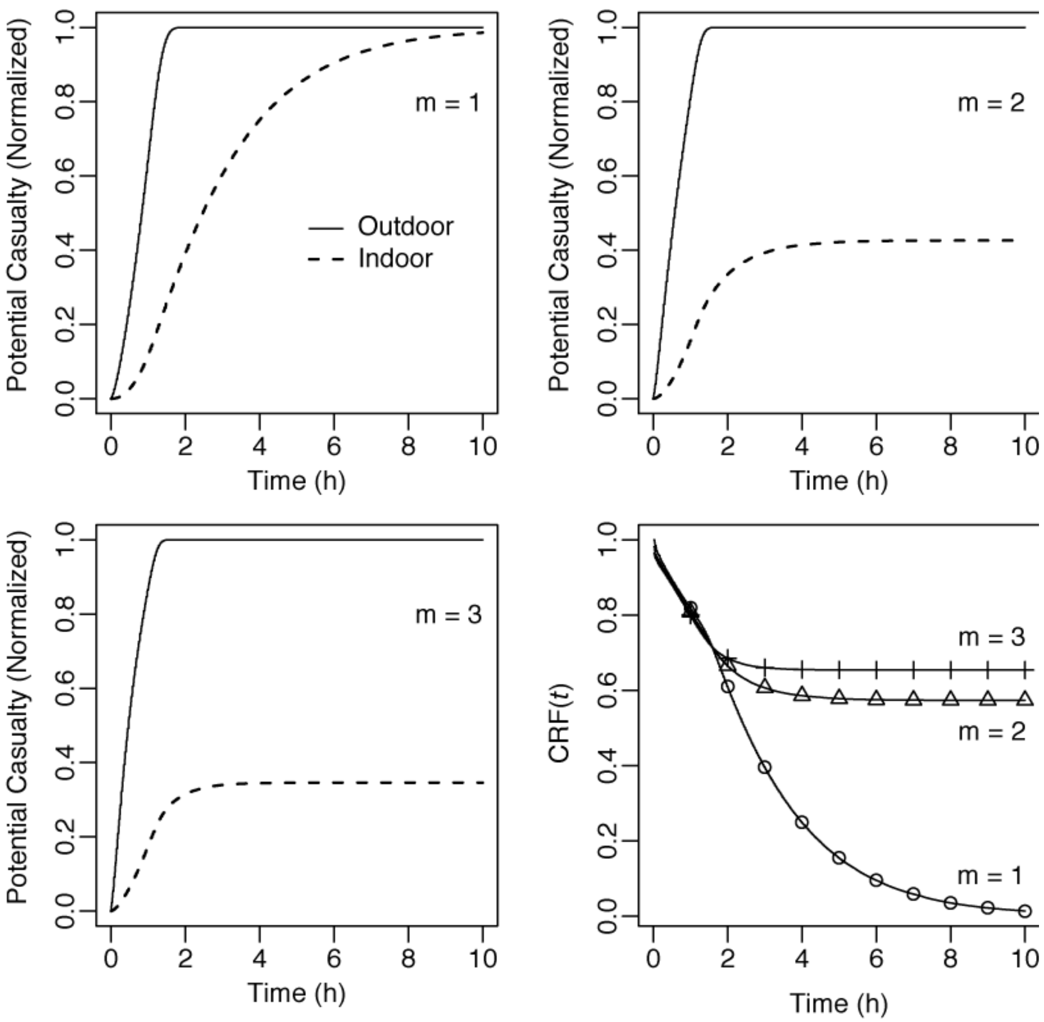
    - However, for releases of long duration, even a moderate release will eventually get indoors and cause harm. So, for long-duration releases, CRF is less sensitive to release-amount.

Results 3: effect of Toxic Load Exponent

Toxic Load Exponent, m, strongly influences SIP effectiveness

- For chemicals with m=1, CRF and SFM values will eventually approach zero and one, respectively, as SIP continues. I.e., SIP becomes ineffective.

- Higher toxic load exponent (e.g., m=3) lead to stronger and and more persistent benefits of SIP. This is because reduction in peak-concentration sharply reduces Toxic Load indoors compared to that outdoors



Results 4: delays in SIP termination: general

- For m=2 and m=3, delays in SIP termination cause very modest harm. This is because most of protection has already resulted from the lower peak-exposure indoors, during passage of the plume.

- For cases with m=1, long delays in SIP termination will make SIP ineffective, I.e., CRF will tend to 0, and SFM will tend to 1 as the delay becomes longer and longer

Results 5: delays in SIP termination for m=1

- **SIP termination effects for m=1**

  - In a high-air-exchange building, most of toxic load accumulates during the passage of the plume, and indoor concentrations decay rapidly afterwards. So, delays in SIP termination are less harmful

  - In a low-air-exchange building, less toxic load accumulates during passage of the plume, and indoor concentrations decay slowly. So, delays in SIP termination are more harmful.

Summary - 1

- **We introduced two new metrics (CRF and SFM) for assessing effectiveness of community-scale SIP**
- **Using relatively simple models, we explored the effectiveness of community-SIP as it is influenced by a number of parameters:**
  - Release scale, duration, and meteorology
  - Air exchange rates of shelters
  - Toxic load exponents of the airborne chemical
  - Delays in termination time for SIP

Summary - 2

Top three findings are:

- **Product of release duration and air-exchange-rate influences SIP effectiveness substantially**

- **Toxic load exponent, m, determines if delays in terminating SIP might impact SIP effectiveness. Only for m=1 prompt termination is important.**

- **Variability in air-exchange-rate of shelters should be carefully considered in evaluating SIP as a strategy. There is large variability in air exchange rates in the U.S. building stock (a factor of 10 between the top 5% and bottom 5%).**

Discussion

- More quantitative specific findings are available as LBNL report **LBNL-61686**, and are accepted for publication in an archival journal (*Atmospheric Environment*)

- More detailed analysis has been completed that incorporates sorption and desorption on indoor surfaces, uses realistic plume prediction with variable wind speed and direction, for a specific U.S. urban area. Impacts of delays in initiation of SIP are also presented in that analysis.

Questions?

Turbulence in the Stable Boundary Layer

Chemical-Biological Information Systems
Austin, TX
11 January 2006

Walter D. Bach, Jr. and Dennis M. Garvey
AMSRD-ARL-RO-EV & -CI-EE

JSTO Project: **AO06MSB00x**

Outline

- Acknowledgments
- Objectives
- Approach
- Early results
- Outlook for future
- Conclusions

Acknowledgments

JSTO Program Office

Army Research Laboratory colleagues

Army Research Office sponsored investigators

Graduate students

Objectives

Improve basic understanding of atmospheric turbulence and dispersion in the stable boundary layer (SBL), by developing fundamental understanding of the dynamic processes and evolving structures of the SBL across multiple scales.

Approach

Conduct fundamental (6.1) research

- Leverage existing research
- Develop new initiatives
  - Academic
  - Army lab

Extramural Research

- International Workshop on Stable Atmospheric Boundary Layers
- Leverage existing SBL research activities
- Initiate new SBL research efforts

Intramural Research

- Generation of gravity waves by the nocturnal low-level jet
- Analyses of modeled and observed wind behavior during the Terrain-Rotor Experiment
- Analyses of Mid-IR propagation scintillation, turbulence and stability in SBL's using a new, local scaling approach
- Theoretical analyses of urban and rural SBL's using multi-resolution decomposition methods
- Examination of the differences in aerosol size, orientation, and composition in evolving SBL's, and
- Investigation of differences in stability patterns over complex heterogeneous surfaces

Workshop on Stable Atmospheric Boundary Layer

www.sedonasable.com

Sessions

- *Turbulence in Stratified Environments*
- *Observations - observed structure of SBL's*
- *Modeling the SBL*
- *Heterogeneity in the SBL*
- *R&D Needs, Capabilities and Opportunities*
- *Applications*

Workshop on Stable Atmospheric Boundary Layer

- Parameterizations of SBL must include
  - Gravity waves and wave drag
  - Stability as a function of scale
  - Variable turbulent Prandtl number
  - Refined concept of a critical gradient Richardson number
  - Both turbulent kinetic energy and turbulent thermal energy
  - Rotation
  - Radiation
- Spatial measurement capabilities must be developed or improved
  - Measure temperature and humidity through BL (H&V)
  - Measure BL height – aerosol, temperature, turbulence intensity
  - Resolve lateral motions on larger scales
  - Meandering in low wind conditions
- Surface Heterogeneity
  - A major component of SBL
  - Importance grows with stability
- Scale is Everything

Extramural Contributions

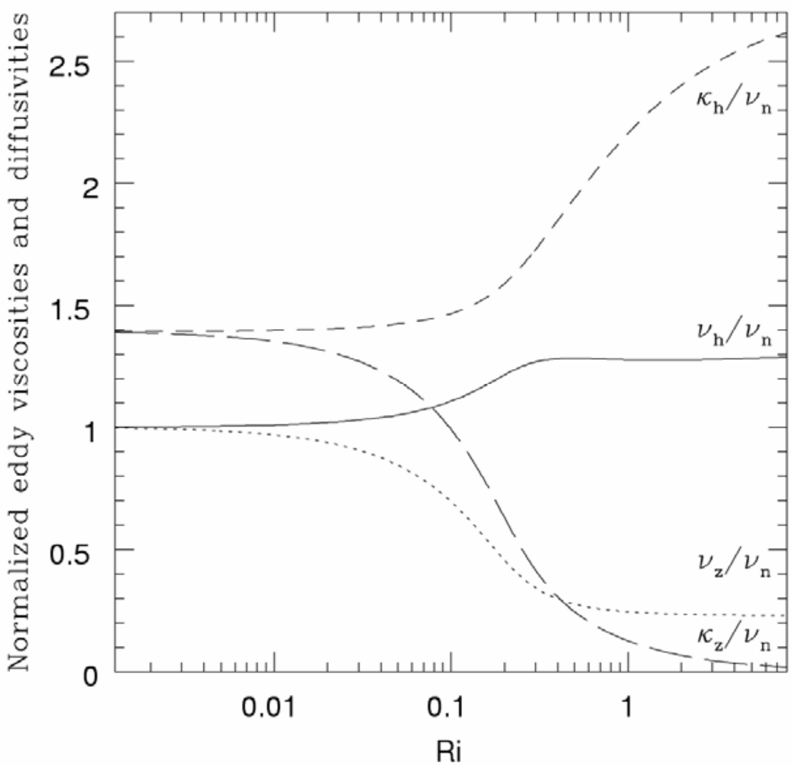
- ***QNSE - A New SBL Closure*** -- B. Galperin, U. South Florida
- ***Dual Doppler lidar in TREX*** -- R. Calhoun, Arizona State
- ***Stable Boundary Layer Evolution*** -- R. Frehlich, CIRES (New)
- ***JORNADA Data Analysis*** -- D. Miller, UConn (New)

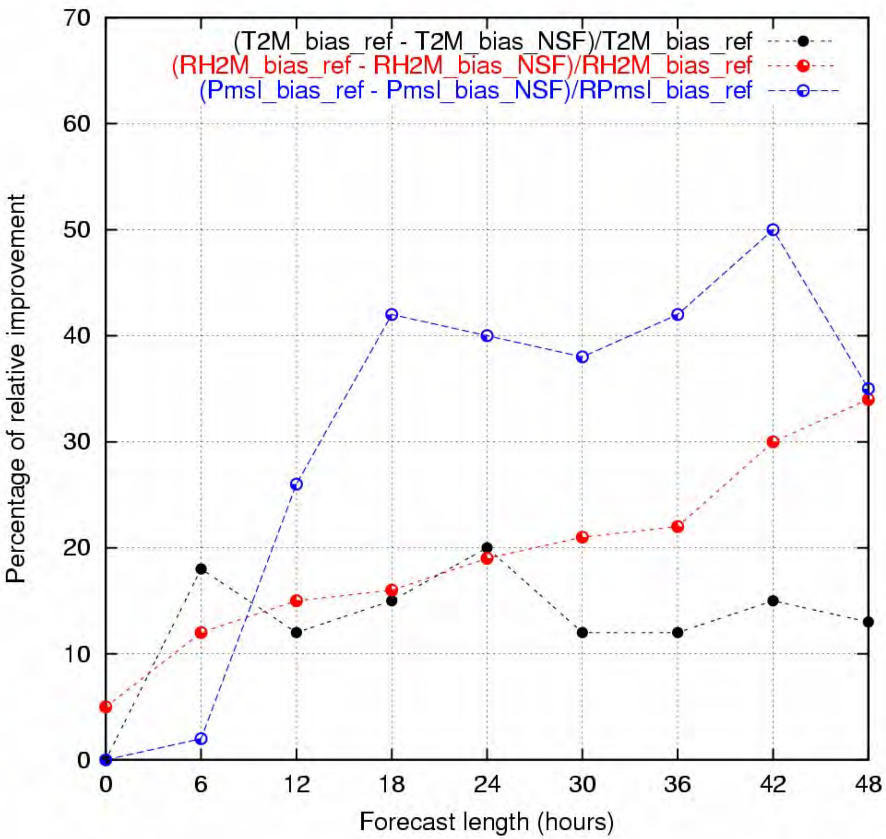
QNSE - A New SBL Closure

Includes turbulent kinetic energy and turbulent thermal energy

Eddy viscosity and eddy thermal diffusivity are coupled laterally & vertically

Application in HIRLAM 12 km grid shows ~15% reduction in bias of surface T, P, RH



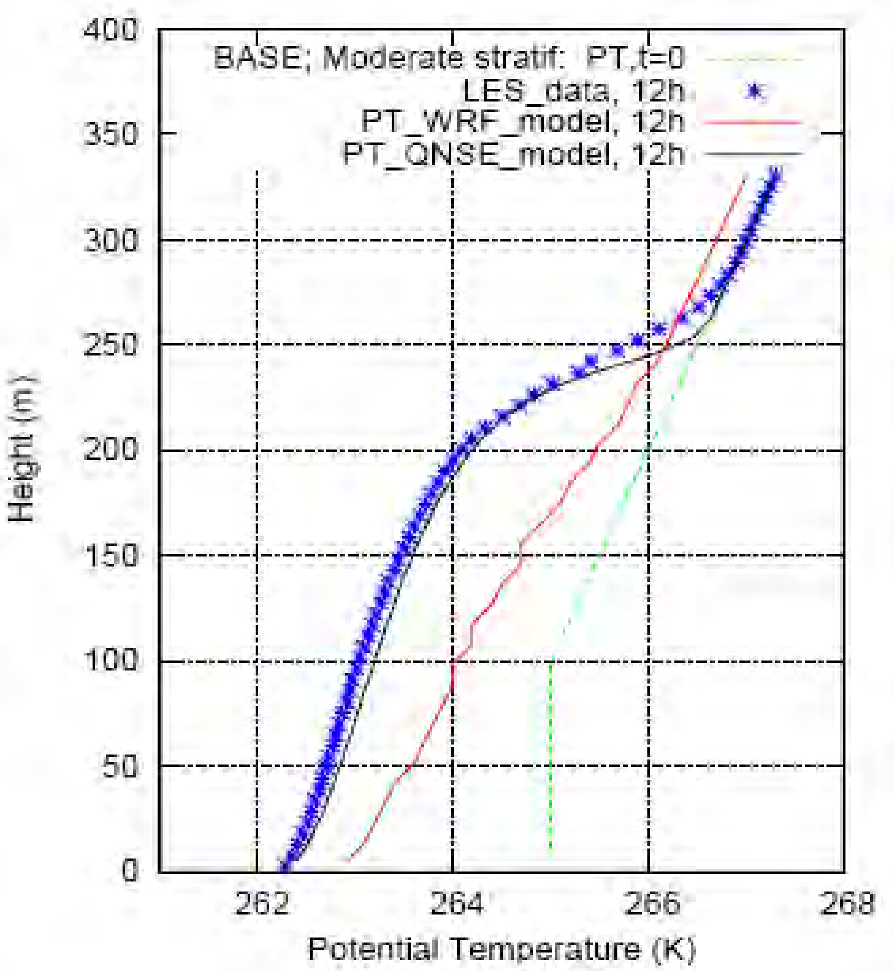


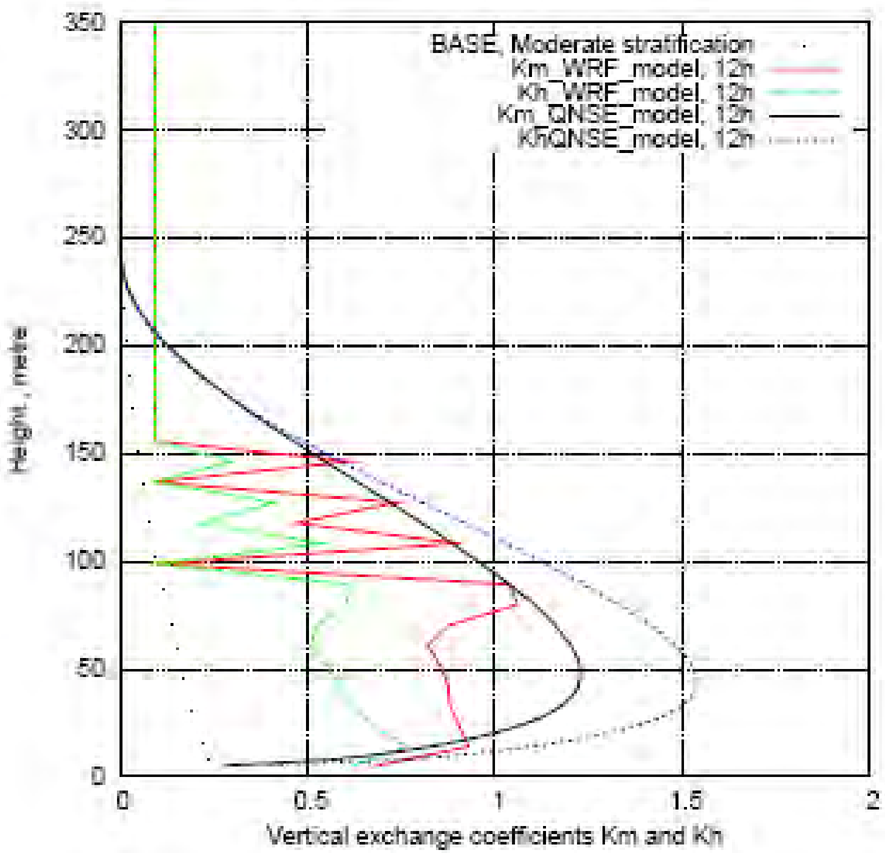
QNSE - A New SBL Closure

- Introduce, test and evaluate closure in WRF PBL model.
- Test and evaluate in high-res HIRLAM
  - Effects of grid size – lateral & vertical
  - Helsinki winter data for wind profiles, mixing height(s), heat flux, surface friction
- Test and evaluate in high-res WRF
  - Using NCAR test scenarios
  - T-REX simulations and observations
  - Incorporate into WRF PBL options

QNSE - A New SBL Closure

Single column intercomparison with WRF (PRELIMINARY)



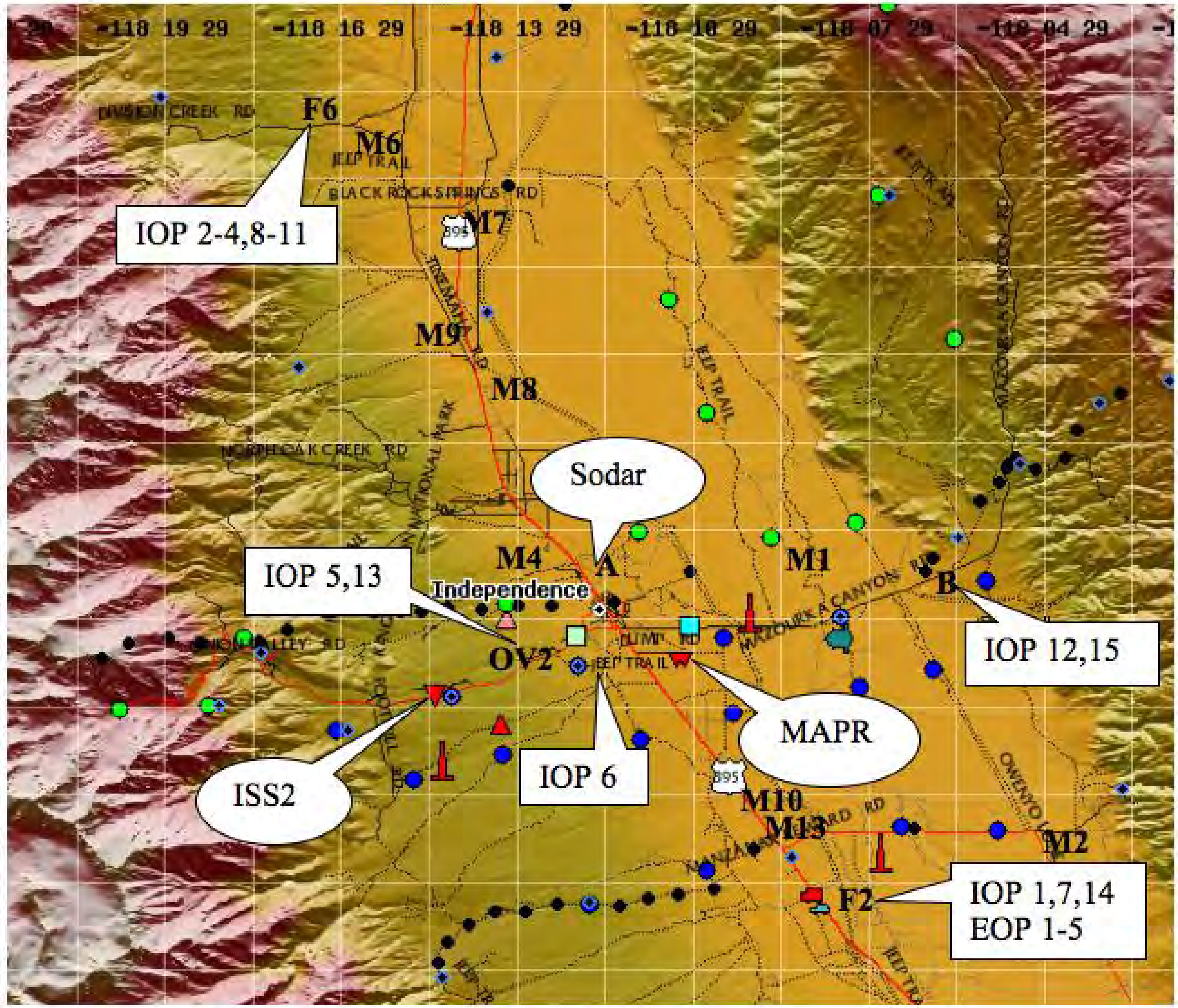


Analyses of Modeled and Observed Winds during T-REX

Terrain - Rotor Experiment

Owens Valley, CA

March-April 2006



Analyses of Modeled and Observed Winds during T-REX

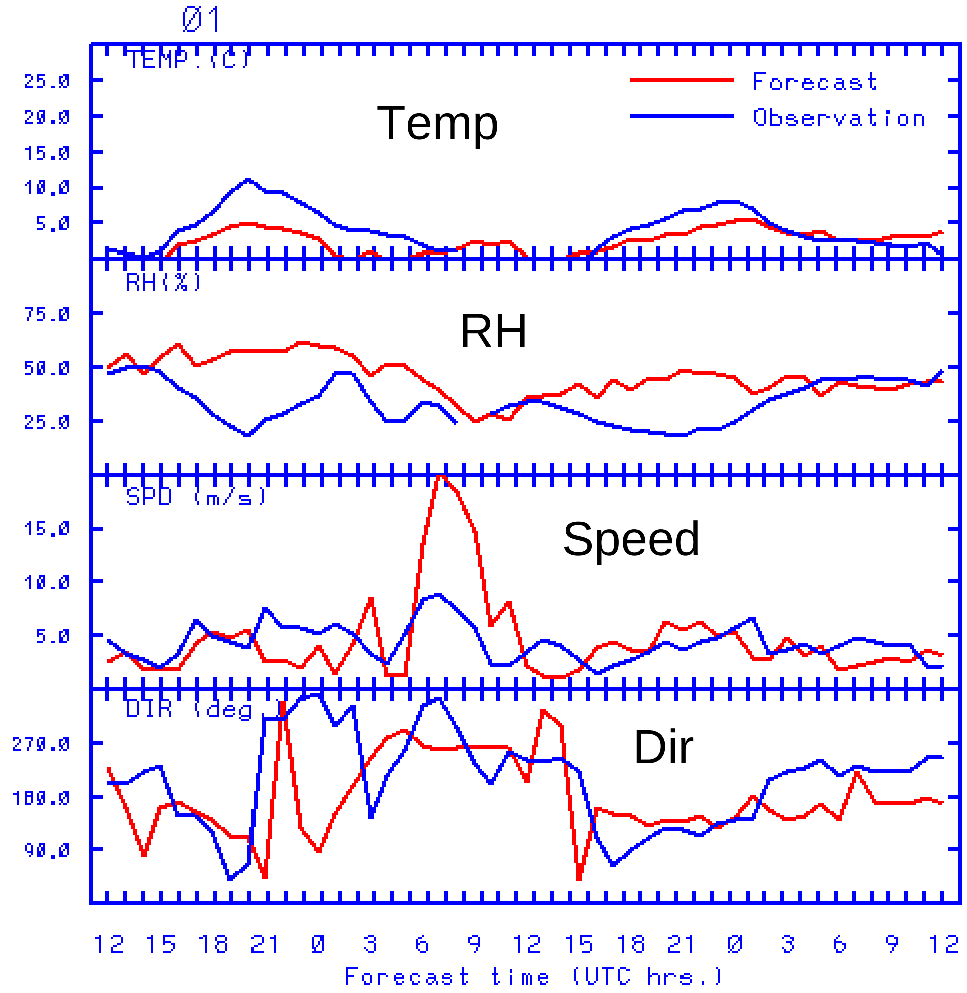
- ARL & AHPCRC supporting a 1 km ΔX version of WRF in real time for T-REX studies.
- Analyses of WRF-ARW forecasts during T-REX by examining data at surface and aloft
  - Evaluate Inherent Uncertainty of forecast quantities and their dependence on height AGL.
  - Representation of PBL wind scales through spectral and multi-scale decomposition techniques.
  - Representation of observed vertical and horizontal wind shear by forecasts.

Analyses of Modeled and Observed Winds during T-REX

48 hour forecast verification beginning 12 March 1200 GMT at DRI surface station #1

Forecast is too cool in day, too warm at night (affects RH)

Wind speed / direction miss significant changes at night.

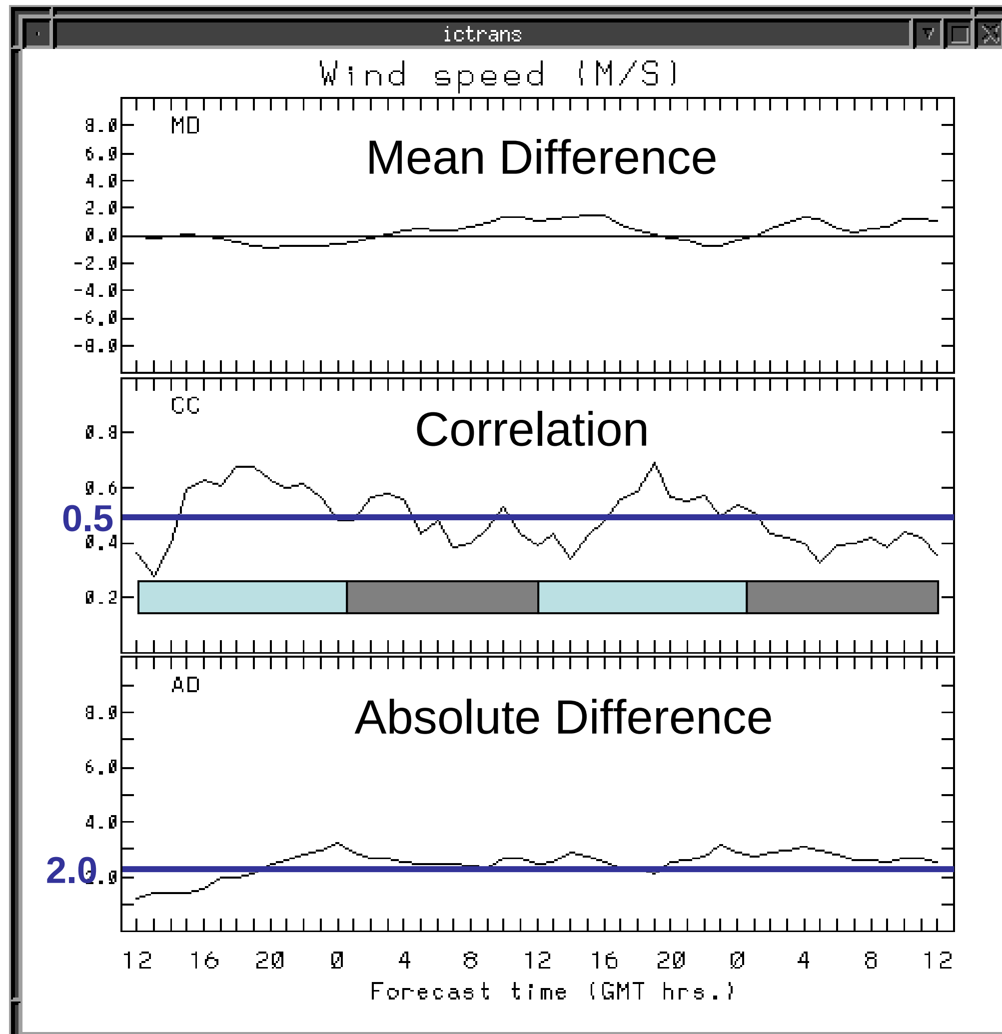


Analyses of Modeled and Observed Winds during T-REX

Error Analyses of hourly averaged WRF forecast winds with observed DRI surface station winds for cases considered to date.

- Mean F-O differences are small
- Correlation is small (~0.4 – 0.6) and declines in 20 to 12 GMT periods
- Mean absolute difference is ~ 3.0 m/s through forecast period.

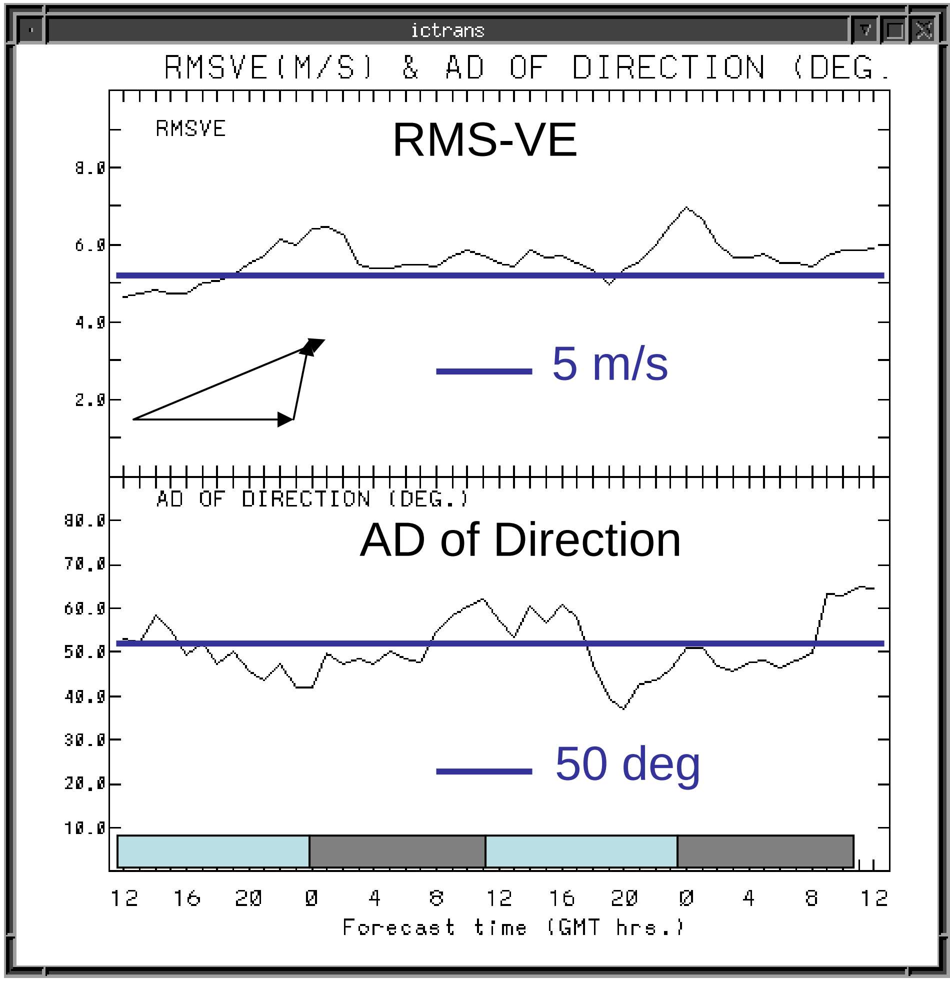
Wind Speed m/s



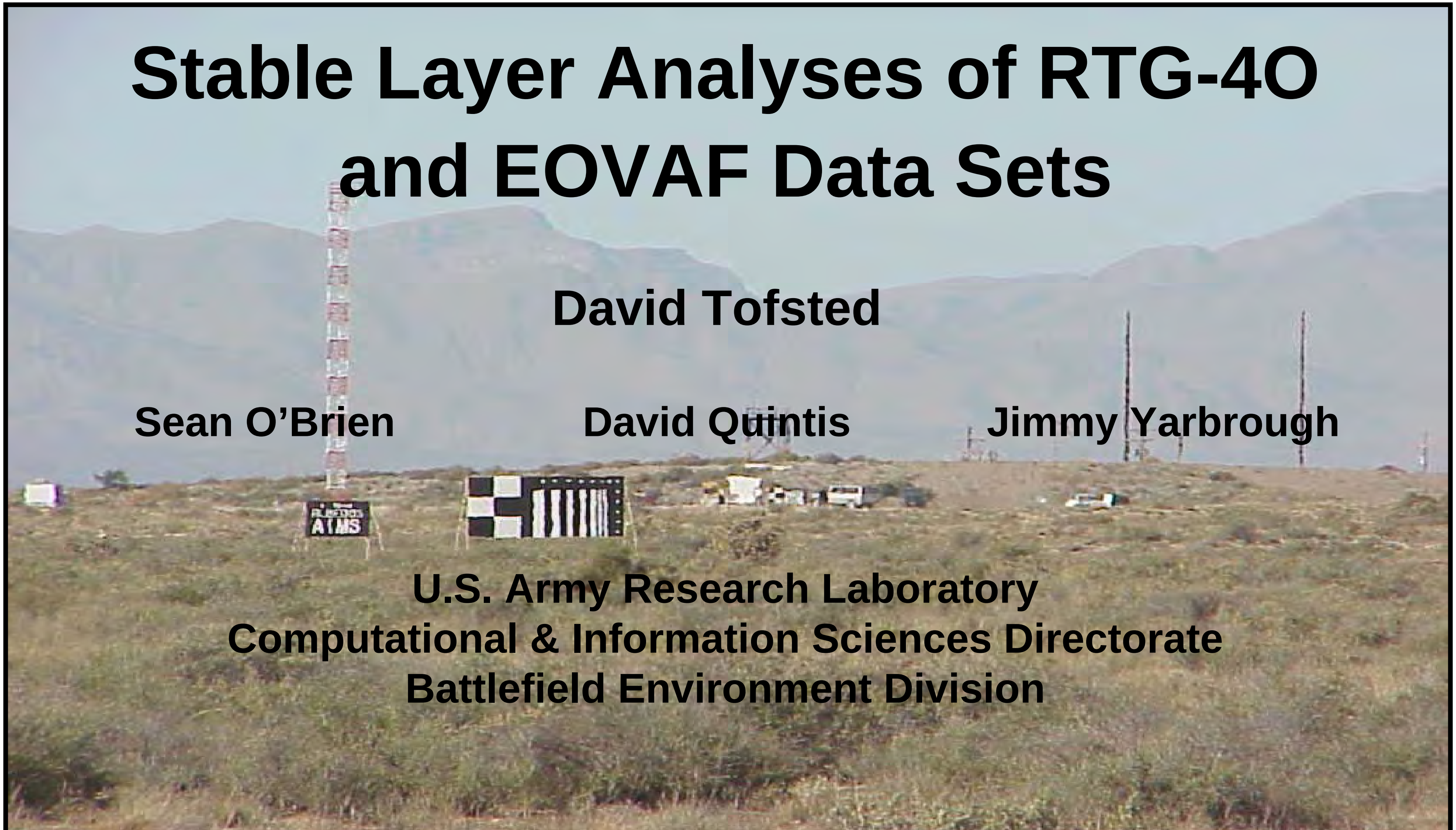
Analyses of Modeled and Observed Winds during T-REX

Error Analyses of hourly averaged WRF forecast winds with DRI surface station winds for cases considered.

- Large RMS vector speed error
- Large Absolute error of wind direction – typical of other studies.



Local Scaling for Mid-IR Scintillation and Turbulence



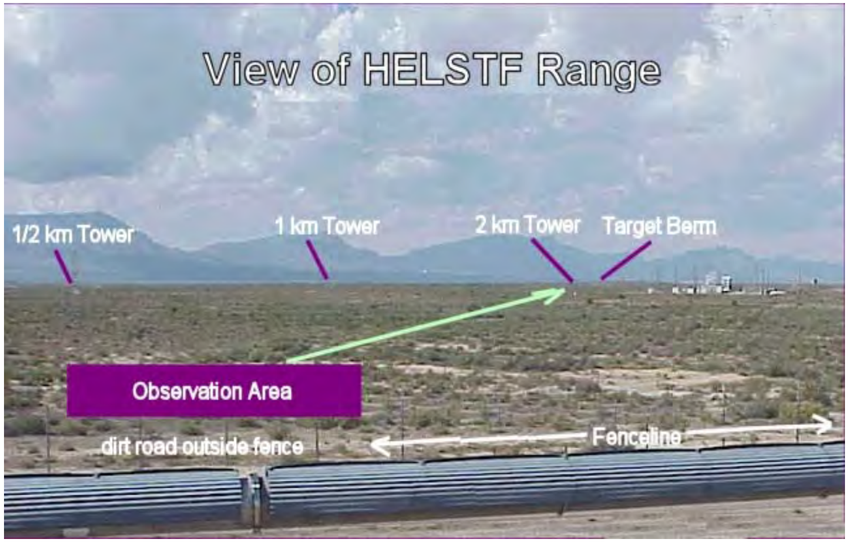
Stable Layer Analyses of RTG-4O and EOVAF Data Sets

David Tofsted

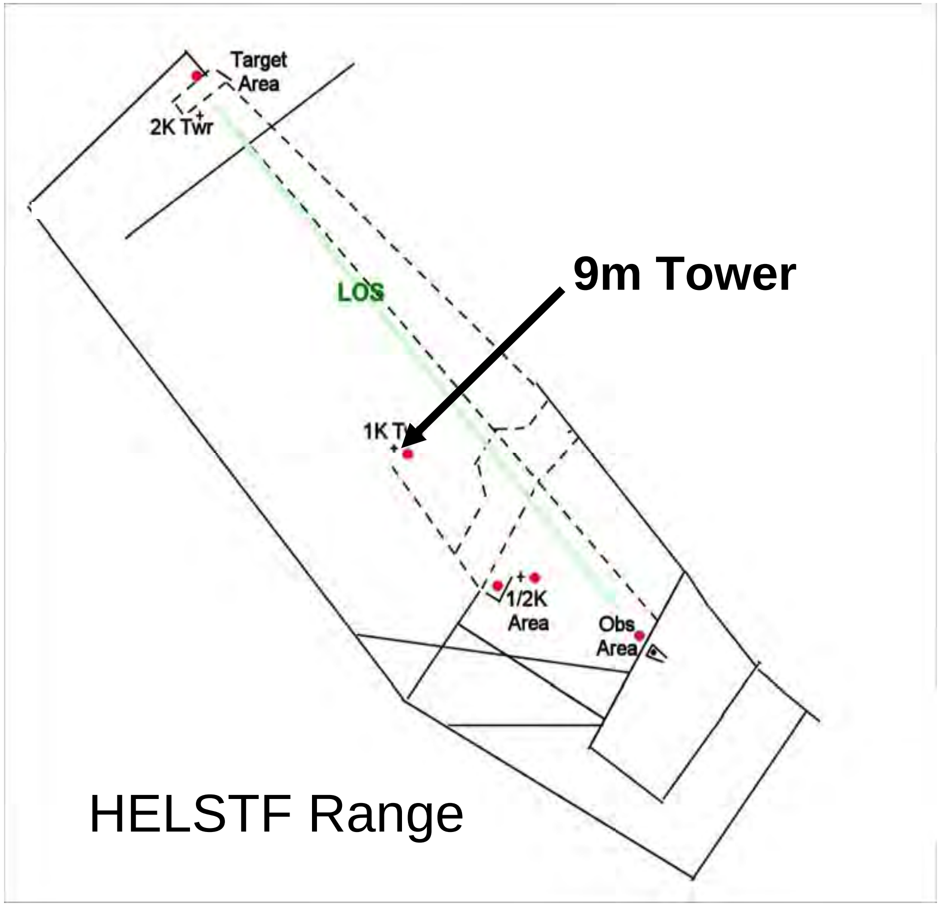
Sean O'Brien **David Quintis** **Jimmy Yarbrough**

U.S. Army Research Laboratory
Computational & Information Sciences Directorate
Battlefield Environment Division

Local Scaling for Mid-IR Scintillation and Turbulence



Tularosa Basin. Roughly 10% foliage cover. Terrain *nearly* flat. November (dry). No precipitation.



Local Scaling for Mid-IR Scintillation and Turbulence

Gradient-based scaling:

$$\begin{cases} u_n(z) = \sigma_w \\ L_n(z) = \sigma_w / (\beta\, dT/dz)^{1/2} \\ T_n(z) = L_n\, dT/dz \\ q_n(z) = L_n\, dq/dz \end{cases}$$

Sorbjan Approach

$$\frac{X}{U_n^a T_n^b Q_n^c L_n^d} = f_x(Ri)$$

Flux-based scaling:

$$\begin{cases} U_*(z) = \tau_w^{1/2} \\ L_*(z) = \tau_w^{3/2} / [\kappa\beta H(z)] \\ T_*(z) = H(z)/U_*(z) \\ q_*(z) = Q(z)/U_*(z) \end{cases}$$

Monin – Obukov Approach

$$\frac{X}{U_*^a T_*^b Q_*^c L_*^d} = f(z/L_*) = const$$

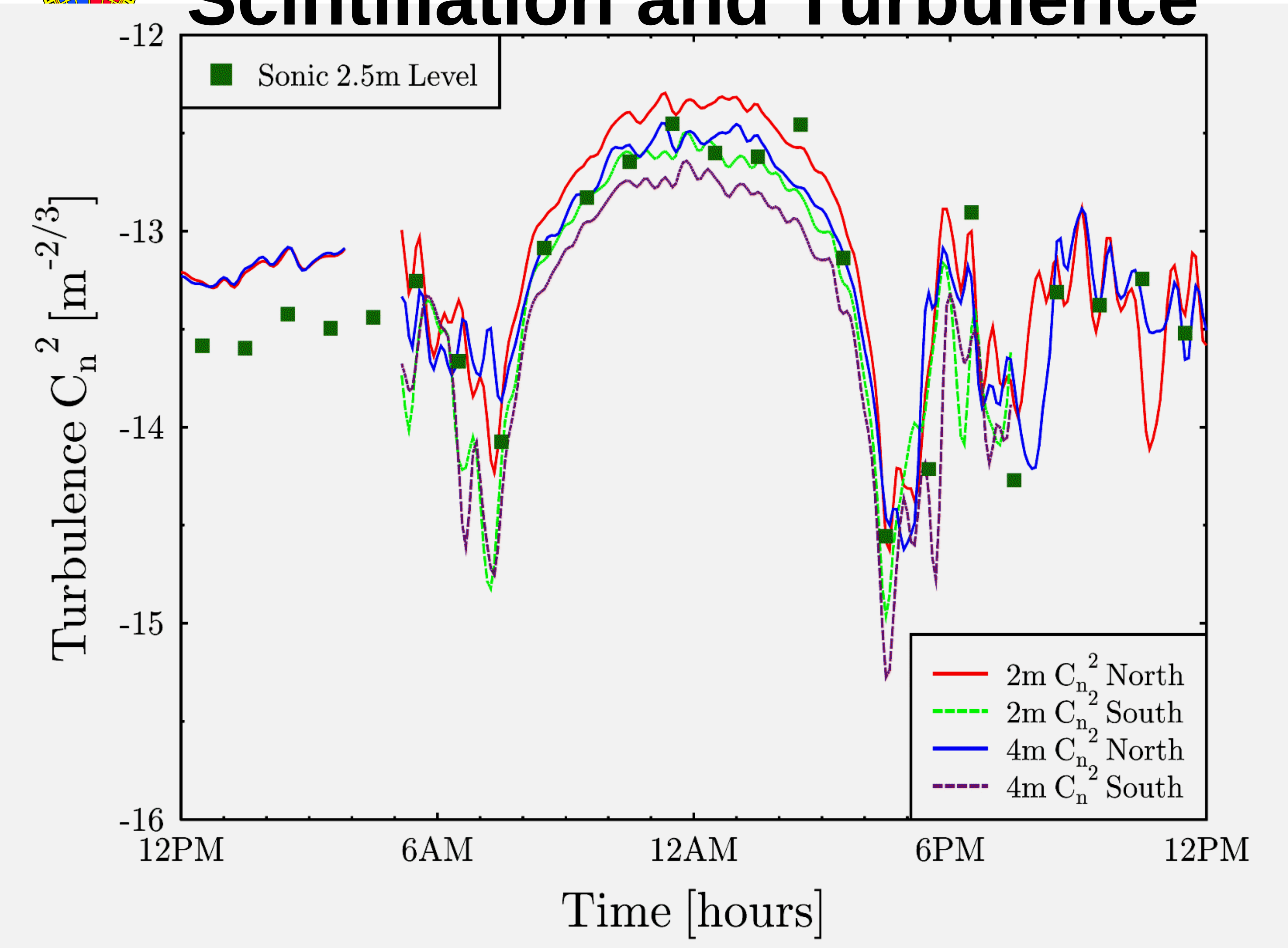
in a "z-less" regime

Local Scaling for Mid-IR Scintillation and Turbulence

Objectives

- Use Sorbjan's alternative scaling concepts for the SBL using EOVAF and HELSTF scintillation and micrometeorology tower data to evaluate scaling parameters and their representation of scintillation (C_n^2)in the SBL.
- Assess the differences in local and flux-bases scaling at representing vertical wind, temperature and moisture profiles
- Assess the presence of gravity waves through temporal analyses of the wind and temperature signals
- Extend an analysis of radiative flux divergence in the first few meters into a model of radiative cooling in near-surface dynamics of the SBL.

Local Scaling for Mid-IR Scintillation and Turbulence



Outlook for the Future

- Workshop report on stable boundary layers should provide extensive recommendations for research directions and opportunities.
- Strong interaction with NCAR-WRF PBL community through Army and NSF actions.
- Report on prospects for physical modeling of SBL

Conclusions

- Developed a diversified study of basic processes in stable boundary layers using theory, models, and observations.
- Very reasonable progress in 8 months.
- Too soon to tell the final outcomes.

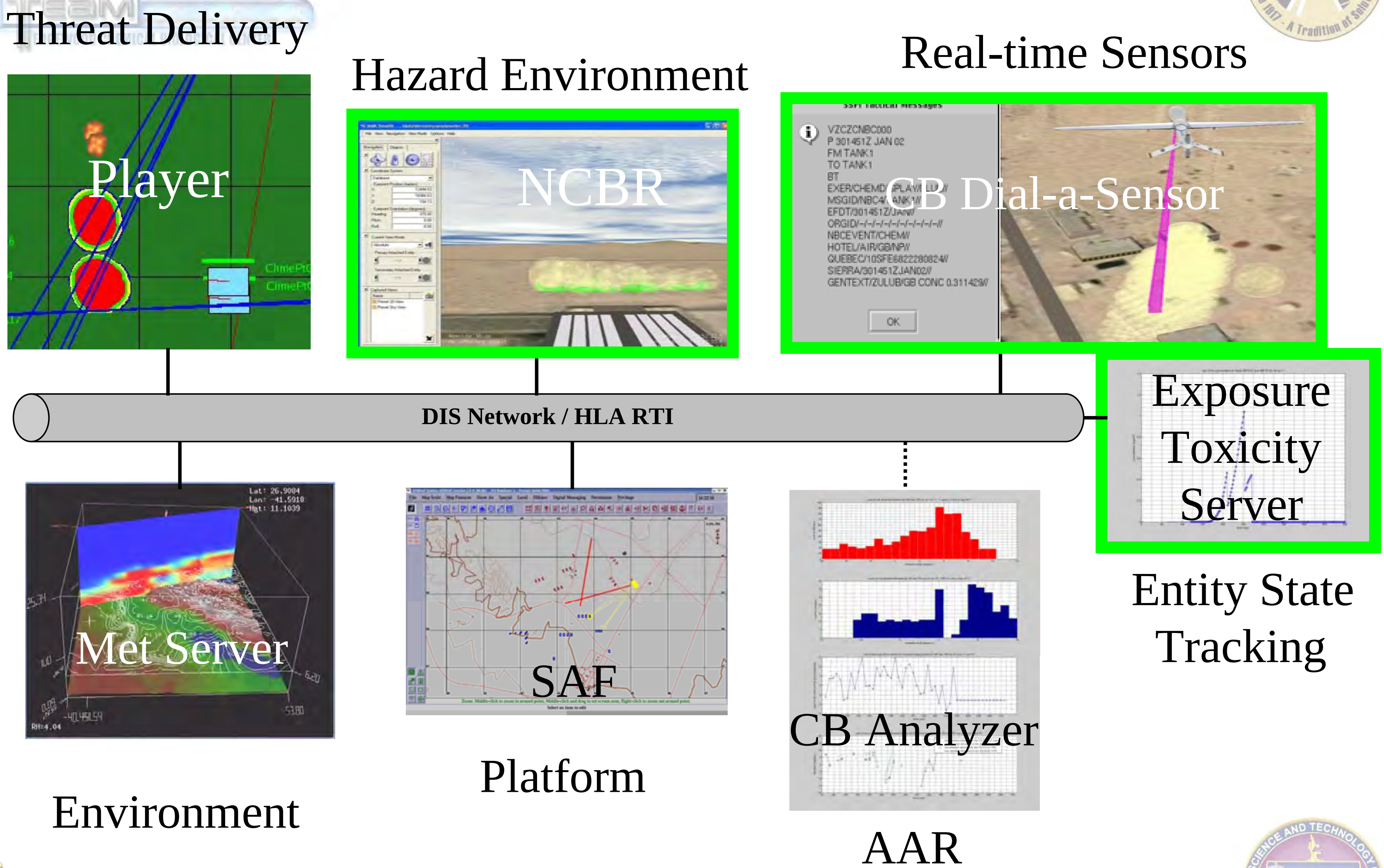
CB System Military Worth Assessment Toolkit

Chris Gaughan, ECBC
Dennis Jones, ITT
Michael O’Connor, ITT

CB Sim Suite

- High Level Architecture (HLA) Compliant Model
- Represents
  - Chem/Bio Threat Propagation/Delivery
  - CB Exposure Effects
  - CB Detection in Constructive and Virtual M&S (OneSAF, Biological Standoff Detection System (BSDS))
  - Radiological Static Grids (FOX trainer)
- TRADOC Battle Lab Collaboration Environment (BLCSE) Model Federate (Interim Approval)
- Modeling Architecture for Technology and Research Experimentation (MATREX) Federate (FY07/08 target)

CB Simulation Suite Architecture



CB Sim Suite is a set of distributed simulation tools designed to represent all aspects of CB passive defense on the tactical battle field for application to analysis, testing, and training.

Uses of the CB Sim Suite

- Supports Army SMART Architecture
  - Development of effective CB defense materiel (requirements analysis)
  - Development of Tactics, Techniques, and Procedures (TTPs)
  - Robust testing over a wide parameter space
  - Broad scenario-based training
  - Simulation-Based Acquisition (SBA)

- Studies ongoing for
  - PM Contamination Avoidance
    - Joint Service Lightweight Standoff Chemical Agent Detector (JSLSCAD)
  - Expeditionary Biological Detection (EBD) Advanced Technology Demonstration
  - JPEO-CBD Future Acquisition Directorate
    - Future Combat Systems (FCS)

- Supports live sensor testing at West Desert Test Center at Dugway Proving Ground

Who Uses the CB Sim Suite?

- ECBC Research & Technology Directorate
  - System R&D, concept evaluation
- JPEO CBD JPM Contamination Avoidance (requirements, R&D)
  - JSLSCAD
  - Artemis
  - Ion Mobility Spectroscopy (IMS)
- JPEO CBD Future Acquisition Directorate
- PM Recon (Fox NBCRV, BIDS, and component trainers)
  - US Army Chemical School
  - Ft. Hood
  - Ft. Polk

Who Uses the CB Sim Suite?

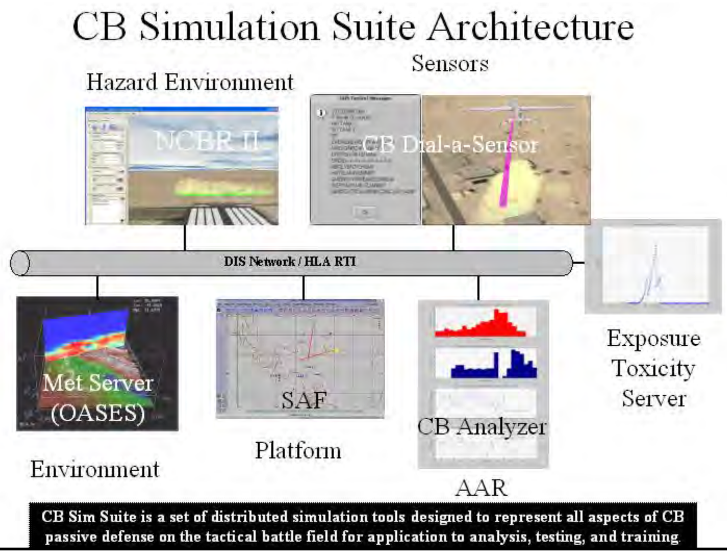
- Army Research Laboratory (ARL)
  - UGV robotics hazard mapping algorithm development
- Army Test and Evaluation Command (ATEC) Developmental Test Center (DTC)
  - Dugway Proving Ground (DPG)
  - Virtual Proving Ground (VPG)
  - Future Combat System (FCS) Combined Test Organization (CTO)
- Army Test and Evaluation Command (ATEC) Army Evaluation Center (AEC)
- Army Maneuver Support Center (MANSCEN)
- Expeditionary Biological Detection ATD (USMC)
- Constructive Simulations

CB System Military Worth Assessment Toolkit, Chris Gaughan, ECBC, BA05MSB030

Objective: Extend the CB Simulation Suite to operate in non-real-time modes using the High Level Architecture's (IEEE 1516) time management capabilities to support military worth assessments at platform through theater levels. The effort will also increase the simulation capabilities of the Sim Suite.

Description of Effort: Modify existing simulations (CB Dial-a-Sensor, CB Exposure Toxicity Server, NCBR) to operate in faster-than-real-time modes

- Add biological toxicological to CB Exposure Toxicity Server
- Add MOPP capability to the Suite, begin preliminary research on implementation of collective protection and decontamination
- Develop interface between CB Sim Suite tools and widely-used constructive simulation



Benefits of Proposed Technology: This capability will provide a more cost effective and timely means of analyzing the impact of CB defense materiel on op tempo, force structure. The capability will also support development better-defined system requirements and development of tactics, techniques, and procedures. The capability will support analyses of fixed sites and mobile forces.

Challenges:

- Development of interfaces between sensor entities and widely-used constructive simulations
- Handling delayed effects of bio exposure through the use of time-management and how that fits into an overall wargame

Maturity of Technology: TRL 4-5. The component models (NCBR Environment Server, CB Dial-a-Sensor, CB Exposure Toxicity Server) are in use for various applications at the CMLS, Dugway Proving Ground, MANSCEN, ECBC, and JPEO CBD.

Capability Area: Modeling&Simulation/Battlespace

Major Goals/Milestones by Fiscal Year

- Final testing of HLA time management in NCBR, ETS, and DAS (FY07)
- Final testing of ETS with biological agent toxicity effects (FY07)
- Complete interface to widely-used constructive level simulation (FY07)
- Update existing user documentation (FY07)

PI Contact Info: Chris Gaughan, (410) 436-5560, chris.gaughan@us.army.mil

Project Overview

- Overall goal: extension of the CB Sim Suite to better support military worth assessments
  - Support non-real-time simulations
  - Support widely-used constructive simulations
  - Study phenomenology effects for future implementation
- Benefit to the Warfighter
  - Cost effective and timely means of analyzing the impact of CB defense materiel
    - Fixed sites
    - Mobile forces
  - Development of better-defined
    - System requirements
    - Tactics, techniques, and procedures

Updating the CB Sim Suite

- Develop and integrate time management into CB Sim Suite elements using HLA time management services
- Extend the existing ETS to include biological elements
- Develop an interface to widely-used constructive simulations

Updating the CB Sim Suite

- **Develop and integrate time management into CB Sim Suite elements using HLA time management services**
- Extend the existing ETS to include biological elements
- Develop an interface to widely-used constructive simulations

Development and Integration of Time Management into the CB Sim Suite

- Updating all major components
  - NCBR
  - ETS
  - DAS
- Provides the ability to
  - Support slower- and faster-than real-time analyses
  - Support theater-level and aggregate-level simulations
  - Continue to support platform-level simulations
- Time management capabilities of HLA runtime infrastructure employed
- The event manager class of each component is updated by utilizing time advance grants from the HLA runtime infrastructure
  - Overhaul of entire code

Time Management Defined

Time Management Definitions

- Coordination
  - Coordinated
    - Time advance is controlled via an external mechanism
  - Independent
    - Time advance is controlled by federates

- Advance
  - Constrained
    - Time advance rate is uniform (across all federates)
  - Unconstrained
    - Time advance rate is **not** uniform (within a federate and/or across federates)

Time Advance and Process Coordination Types

	Constrained	Unconstrained
Independent	•Real-Time and scaled Real-Time •DIS and non-Time Managed HLA	•**N/A** Meaningless in the Context of distributed simulations
Coordinated	•Not used in practice •Requires an external mechanism to control time	•HLA Time Managed •Federation driven time with non-uniform time advance

Time Advance and Process Coordination Types

	Constrained	Unconstrained
Independent	•Real-Time and scaled Real-Time •DIS and non-Time Managed HLA	
Coordina		•HLA Time Managed •Federation driven time with non-uniform time advance

All simulations in the exercise advance independently at the same rate using the same time scale (e.g., 1 sec = 1 sec) (constrained)

Each simulation in the exercise advances at its own (unconstrained) time scale as coordinated by an exercise time/event

MODELING, SIMULATION, & ANALYSIS TEAM
EDGEWOOD CHEMICAL BIOLOGICAL CENTER

Time Management Implementation

NCBR, DAS, & ETS Baseline

	Constrained	Unconstrained
Independent	•Real-Time and scaled Real-Time •DIS and non-Time Managed HLA	
Coordinated		LA Time Managed •Federation driven time with non-uniform time advance

Mil Worth

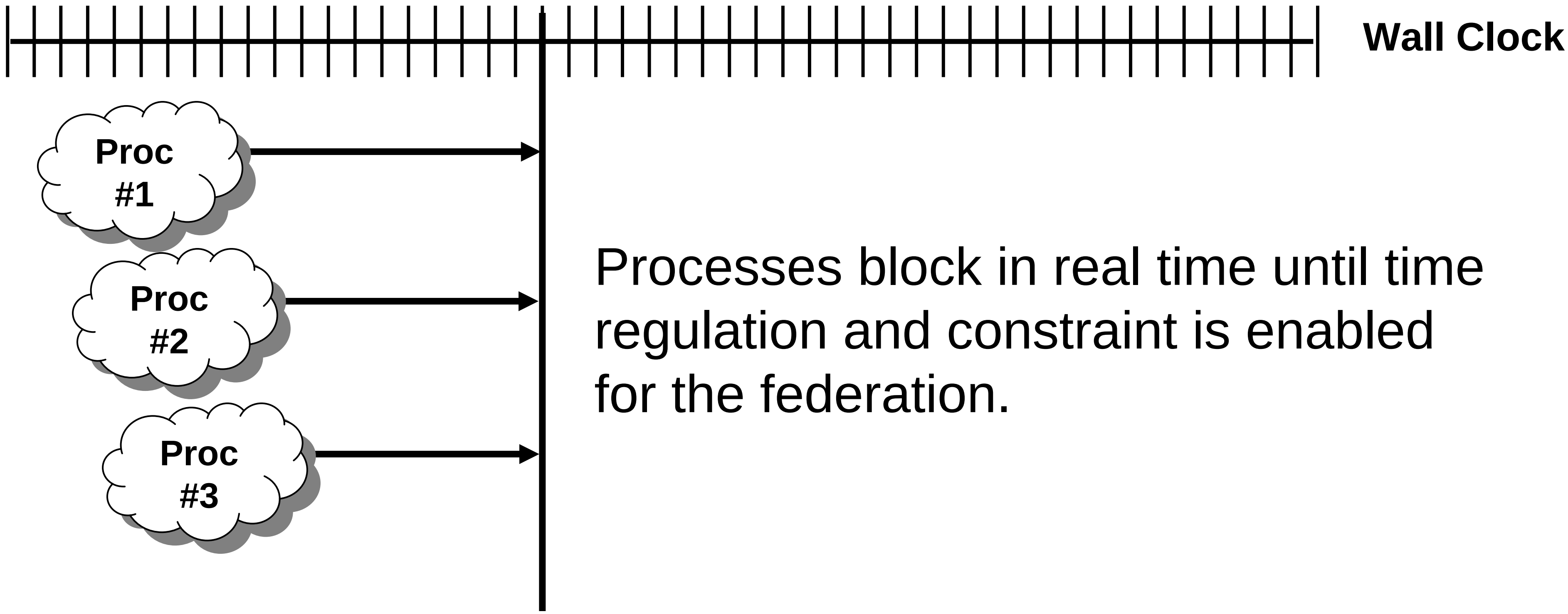
NCBR, DAS, & ETS End State

ITT
Engineered for life

How Time Management Works

Process Initialization

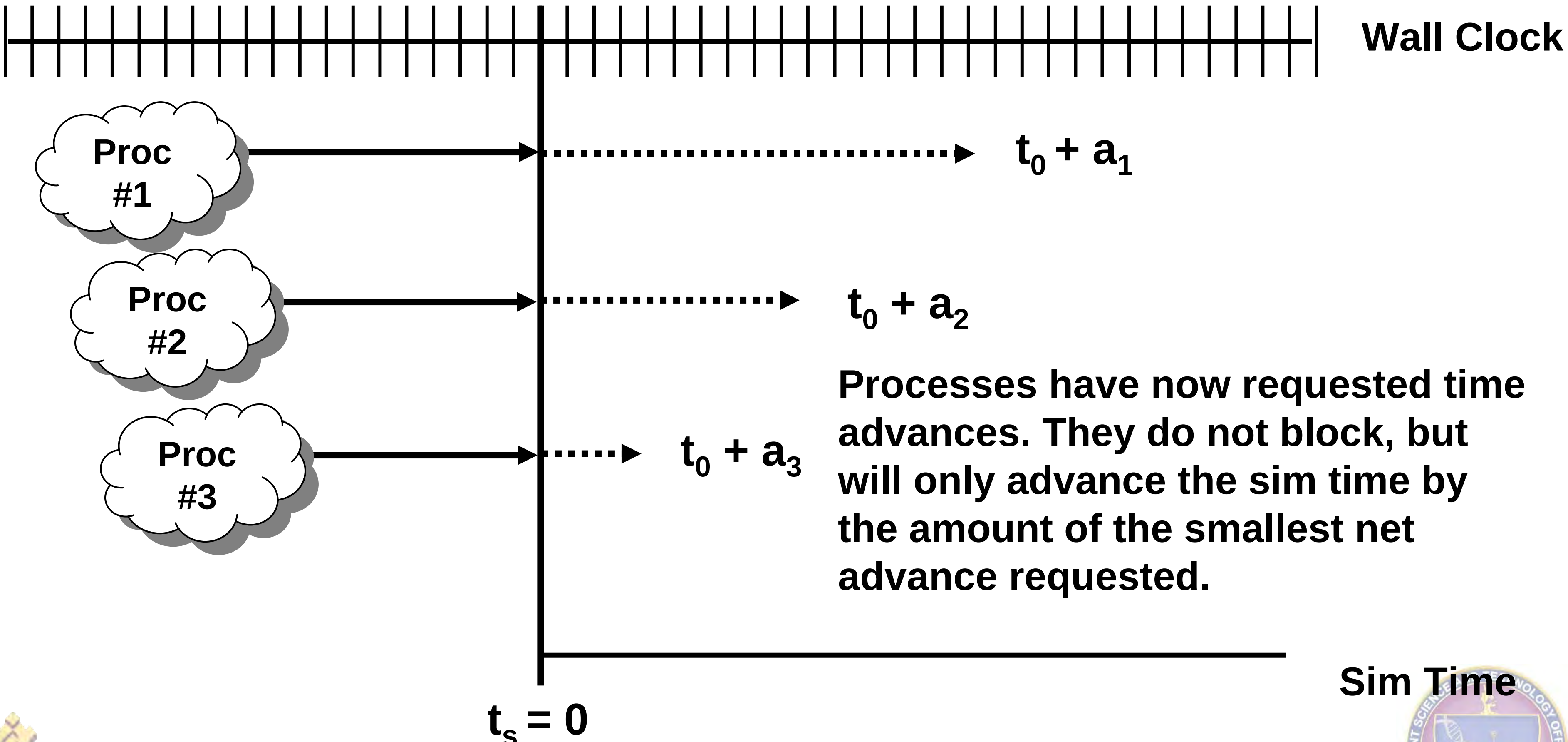
- **Initialize Process**
- **Request Time Regulation/Constraint**



Processes block in real time until time regulation and constraint is enabled for the federation.

Process Execution

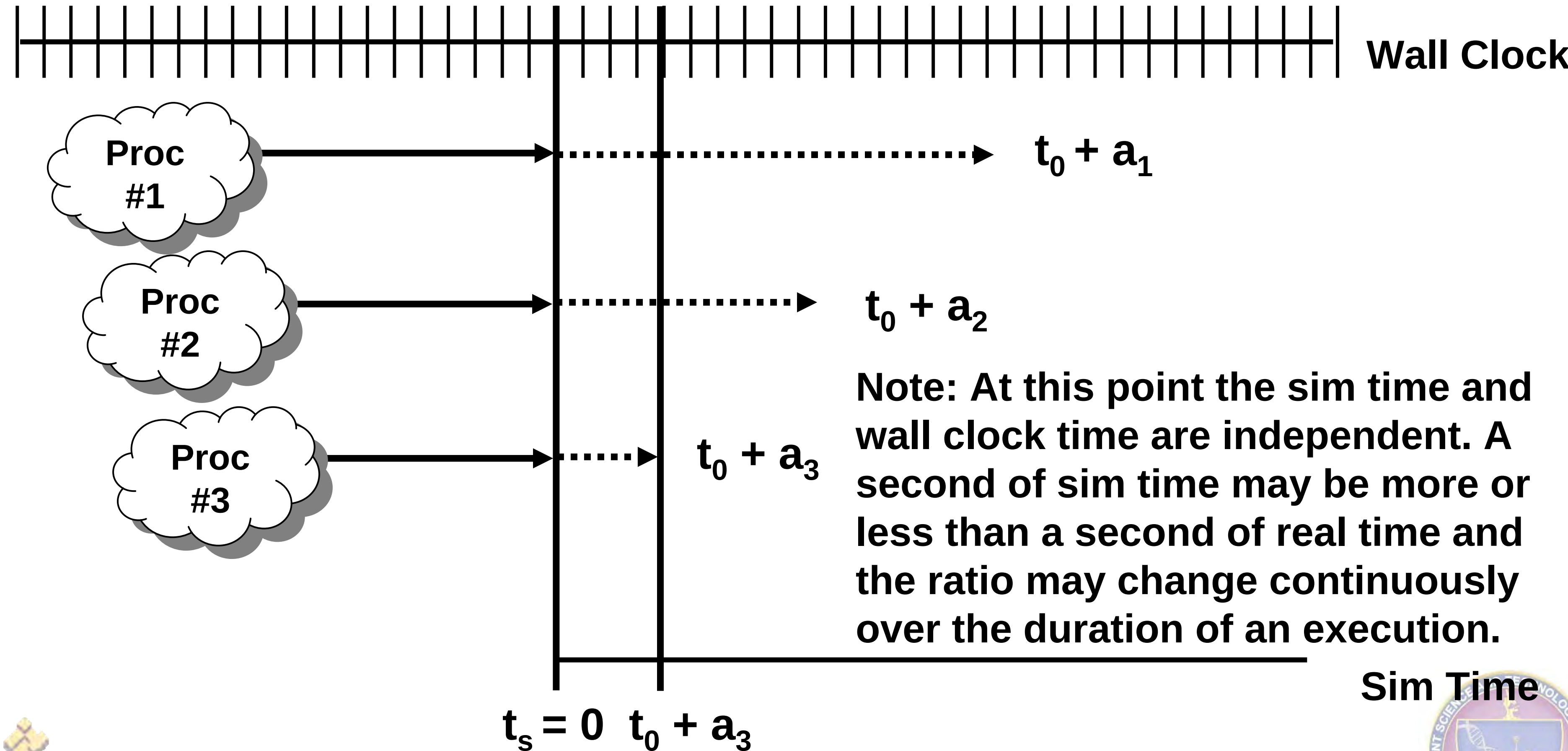
- Time Regulation/Constraint started
- Request Initial Time advance



Processes have now requested time advances. They do not block, but will only advance the sim time by the amount of the smallest net advance requested.

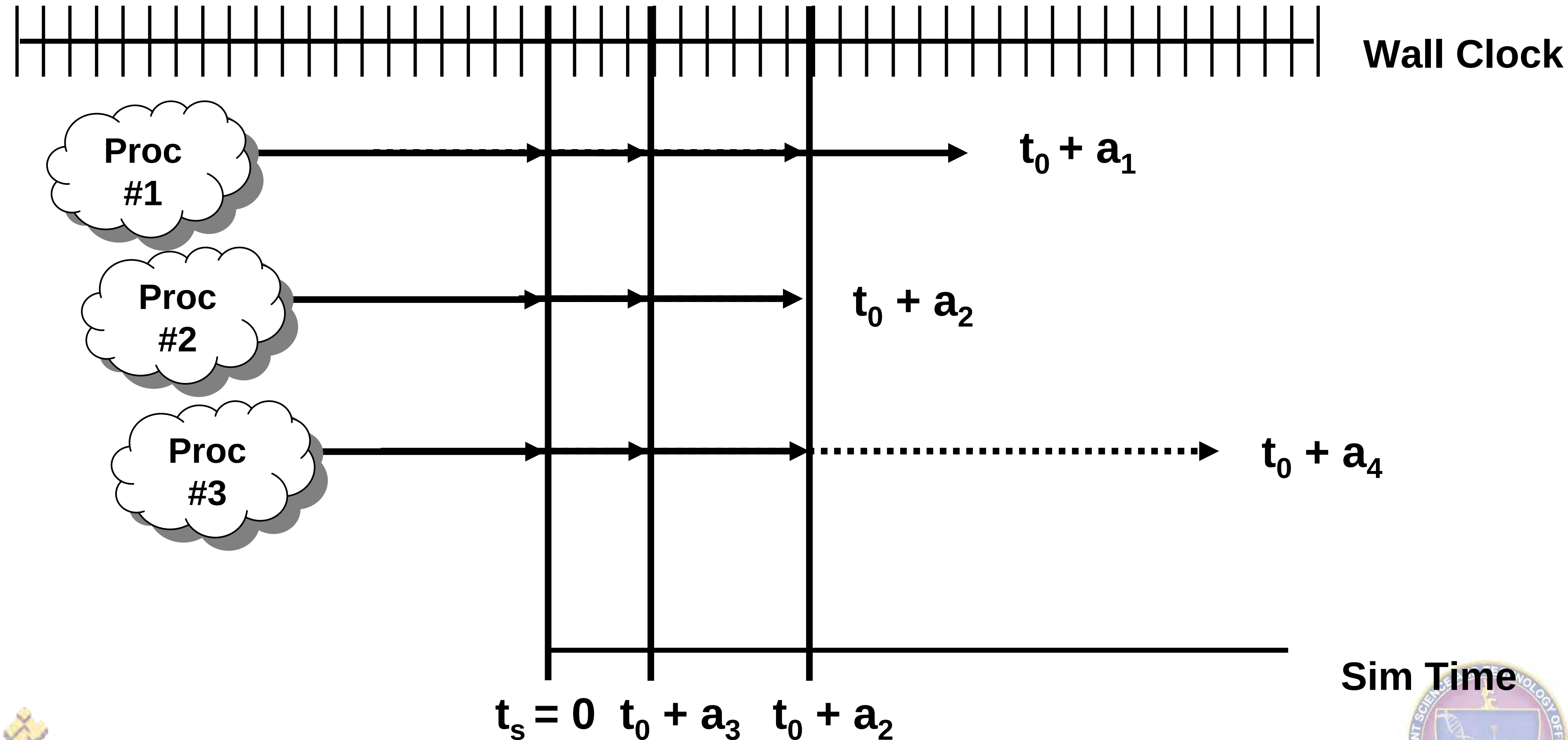
Process Execution

- **All the processes now complete any processing to get to time t0+a3**



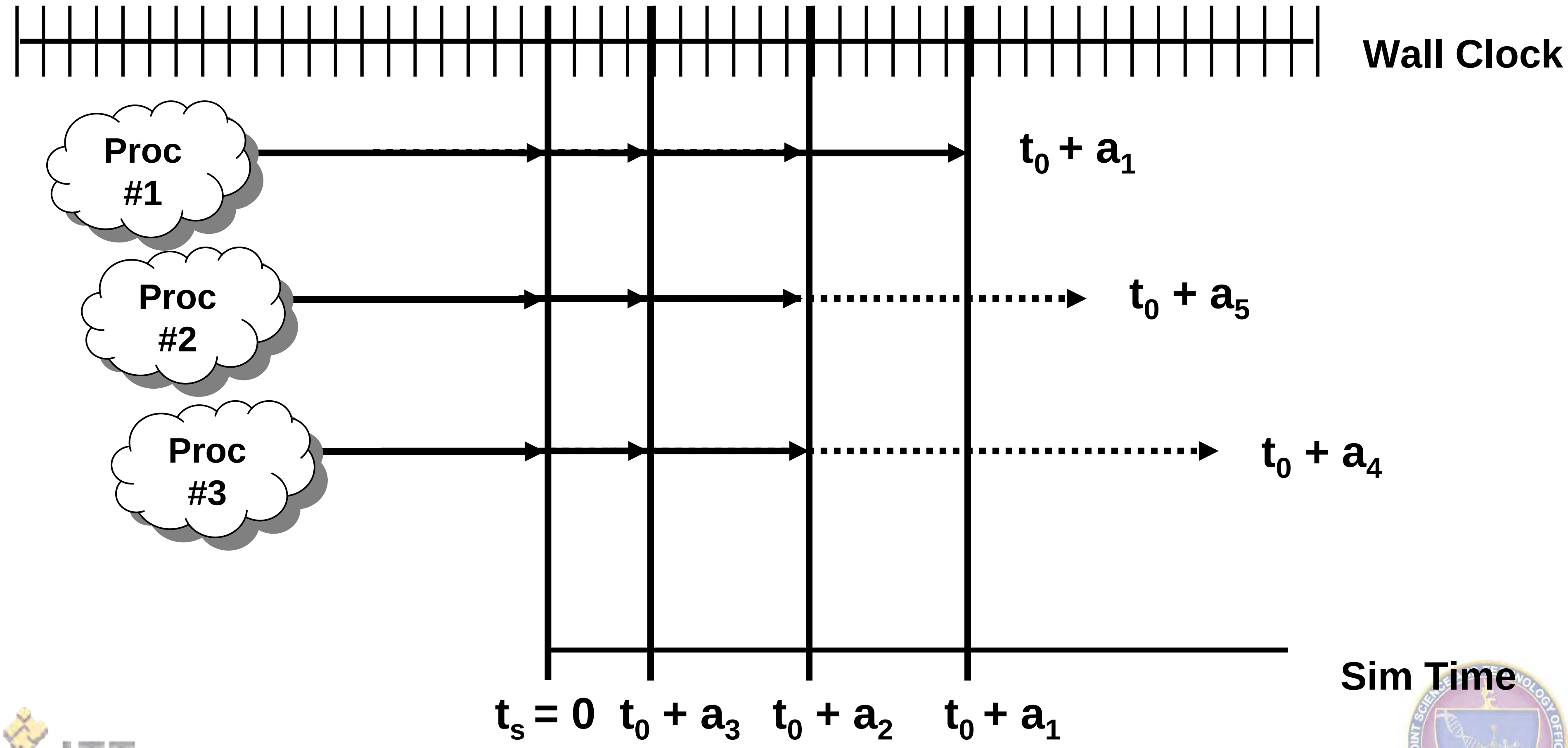
Process Execution

- **Proc #3 then issues another Time Advance Request**



Process Execution

- **Next Iteration**



Updating the CB Sim Suite

- Develop and integrate time management into CB Sim Suite elements using HLA time management services

- **Extend the existing ETS to include biological elements**

- Develop an interface to widely-used constructive simulations

Extend the existing ETS to Include Biological Elements

- Use a community-accepted toxicity model
  - LD_{50} and probit slope used
    - Recommendation from senior community
    - Derived from chemical methodology
      - All three algorithms [8-10] selectable
    - Limited agent data available

- Bio considerations for future work
  - Delay between exposure and onset of symptoms/impacts
  - Most simulations do not last long enough for onset of effects
  - Need the capability to work exposure portion then effects portion
    - Predosing
    - "Jump time" during simulation/non-real-time simulation
      - Non-trivial problem
      - Research area

Updating the CB Sim Suite

- Develop and integrate time management into CB Sim Suite elements using HLA time management services
- Extend the existing ETS to include biological elements
- **Develop an interface to widely-used constructive simulations**

Develop an Interface to Widely-Used Constructive Simulations

- Happening now (FY06/07): Battle Lab Collaborative Simulation Environment (BLCSE)

- Happening soon (FY07/08): Modeling Architecture for Technology and Research Experimentation (MATREX)

- Modifications required on both sides of the interface
  - Inputs from the SAF drive the Sim Suite
    - Flags need to be added for MOPP, etc.
  - Outputs from the Sim Suite need to affect the behaviors of the SAF
    - Effects of CB insults need to be modeled in the SAF behaviors
      - This is happening in the BLCSE

Updating the CB Sim Suite

- Develop and integrate time management into CB Sim Suite elements using HLA time management services
- Extend the existing ETS to include biological elements
- Develop an interface to widely-used constructive simulations

Other Current Sim Suite Work

- JSTO MSB (FY06-07)
  - Verification of the CB Sim Suite
  - Robust User Documentation
  - Preliminary GUI development

- ATEC/FCS CTO upgrade of NCBR and DAS for FCS T&E (FY04-FY10)
  - Urban environments
  - Higher fidelity sensor representations in DAS ("ROC" curves)
  - Independent verification

- JSTO T&E (FY06-FY08)
  - Currently defining requirements for M&S architecture to support T&E
    - Collective Protection
    - Individual Protection (FY07)
    - Contamination Avoidance

CB Sim Suite

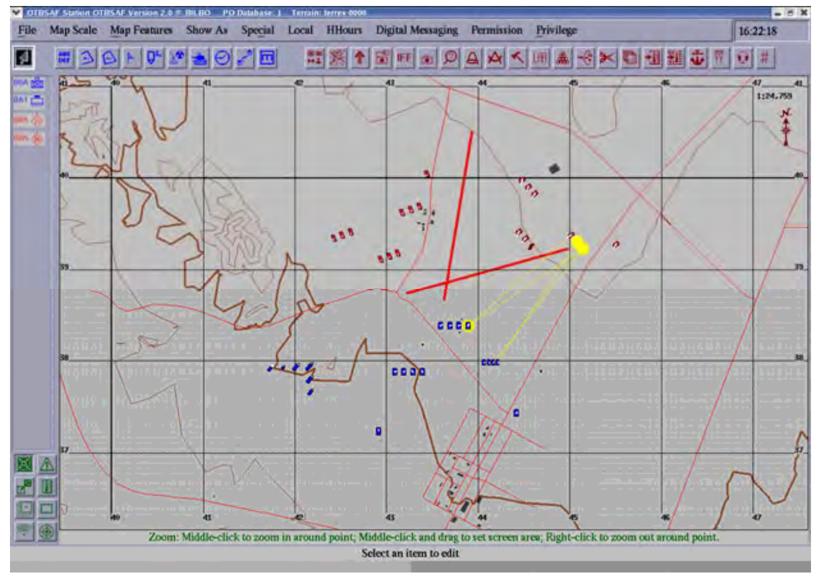
- High Level Architecture (HLA) Compliant Model
- Represents
  - Chem/Bio Threat Propagation/Delivery
  - CB Exposure Effects
  - CB Detection in Constructive and Virtual M&S (OneSAF, Biological Standoff Detection System (BSDS))
  - Radiological Static Grids (FOX trainer)
- TRADOC Battle Lab Collaboration Environment (BLCSE) Model Federate (Interim Approval)
- Modeling Architecture for Technology and Research Experimentation (MATREX) Federate (FY07/08 target)

Questions or Comments?

Backup Slides

OneSAF Testbed Baseline

- Managed by PEO STRI
- Entity-level distributed simulation that represents combined arms tactical operations up to the battalion level
- Entities behave semi-autonomously
  - Entity behaviors and tactics generated based on orders to top-level units or subordinate units



PEO STRI (Program Executive Office for Simulation, Training and Instrumentation)

NCBR

- Simulates multiple CBR events simultaneously in real time
  - Expanded to include smoke propagation
  - Nuclear support in previous version release
    - No current customers
- Validated physics-based models for hazard propagation
  - DTRA's SCIPUFF
  - NSWC's VLSTRACK
- Terrain and meteorology effects
  - 4D met—external/OASES or scripted feeds
  - 3D terrain (CTDB, ERC)

Medium Range Missile GB release
yellow -> vapor green -> aerosol

ITT
Engineered for life

NCBR

- Communicates environment information with other simulators
  - DIS, HLA compliant
  - Hazard output (outputs gridded, 3D hazard data)
    - 3D Gaussian puffs (air concentration – vapor and aerosol)
    - 2D conformal grids (concentration, dose, ground deposition)
    - Post processing to XML output
  - Supports
    - Sensor modeling (point, standoff)
    - 2D/3D visualization
    - Exposure modeling (ETS)

Player

- Performs the hazard delivery

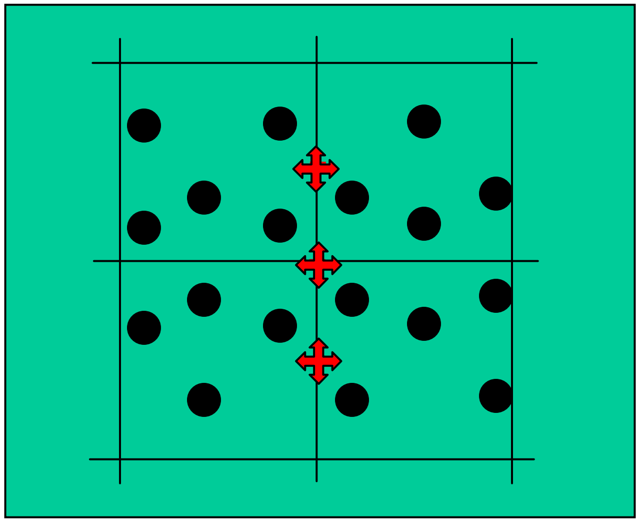
- Detonation
  - Standard munition/agent combination
    - 122 Artillery
    - 152 Artillery
    - Small Rocket
    - Large Rocket
    - 100 kg Bomb
    - 250 kg Bomb
    - 500 kg Bomb
    - 1000 kg Bomb
    - Medium Range Missile
    - Long Range Missile
    - Cruise Missile
  - Chem point sprayer detonation
  - Chem point source detonation

- Laydown
  - Artillery Volley – 6 shells (1 Battery)
  - Small Artillery – 18 shells (1 Battalion)
  - Medium Artillery – 54 shells (3 Battalions)
  - Small Bomb – 2 bombs side by side
  - Medium Bomb – 4 bombs in a square pattern
  - Large 500k Bomb – 8 bombs
  - Large 1000k Bomb – 4 bombs
  - MLRS Battery – 240 Shells
  - MLRS Battalion – 720 Shells

Small Laydowns

- 122 mm Battery, 3 rounds – Equivalent of a 122 mm battery arrayed in a "lazy W", firing 3 volleys, at aimpoints 50 meters apart in range. See pattern below.

  18 rounds x 2 kg agent/round x 60% dissemination efficiency = 21.6 kg of agent



Grid line spacing = 100 meters

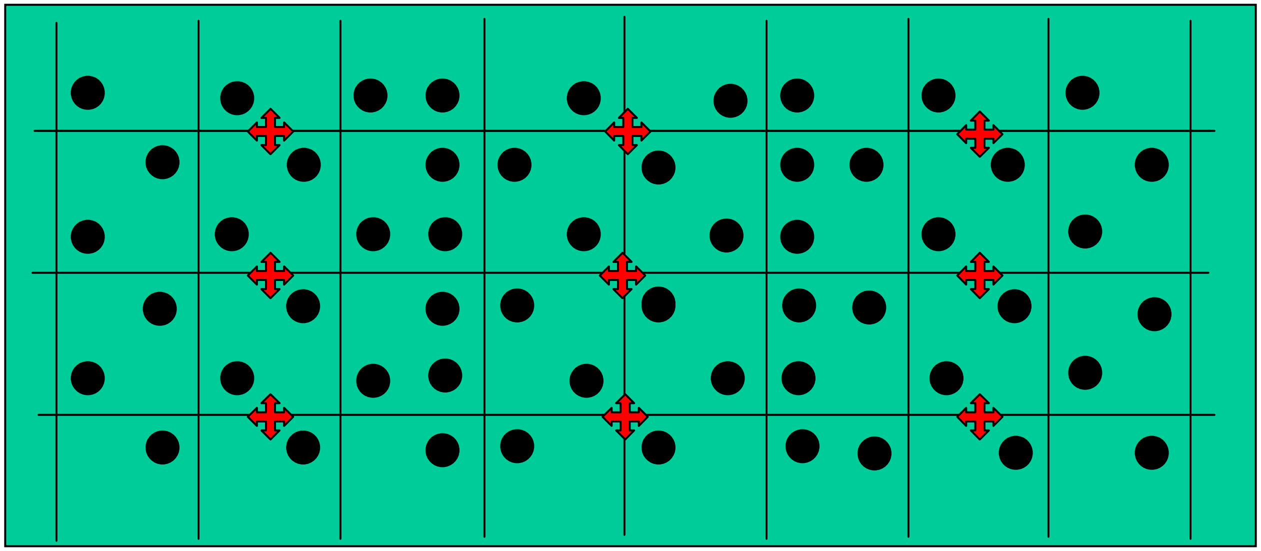
aimpoints

- 2 x 100 kg bombs, simultaneous impact 50 meters apart.

  2 bombs x 25 kg agent/bomb x 60% dissemination efficiency = 30 kg of agent

Medium Laydowns

- 152 mm Battalion, 3 rounds – Equivalent of 3 firing batteries, each firing a volley at aimpoints that are 250 meters apart laterally. Subsequent volleys are at aimpoints 100 meters north and south of initial aimpoints. See pattern below. 54 rounds x 4 kg agent/round x 60% dissemination efficiency = 129.6 kg of agent



Grid line spacing = 100 meters

aimpoints

- 4 x 250 kg bombs, simultaneous impact in square pattern 50 meters apart. 4 bombs x 75 kg agent/bomb x 60 % dissemination efficiency = 180 kg of agent

Large Laydowns

• 8 x 500 kg bombs, simultaneous impact in 2 rows of 4 bombs each, 100 meters between rows and between bombs. 8 bombs x 125 kg/bomb x 60% dissemination efficiency = 600 kg of agent

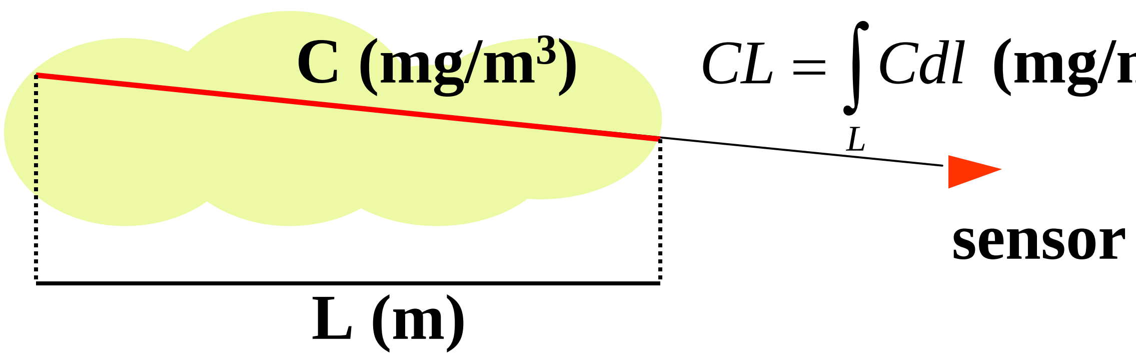
• 4 x 1000 kg bombs, simultaneous impact in square pattern, 150 meters apart. 4 bombs x 300 kg/bomb x 60% dissemination efficiency = 720 kg of agent

CB Analyzer

- CB Analyzer processes logged data at time stamps with both vehicle data and hazard data
- A polar stepped scan pattern is executed for every vehicle time stamp
- Reported data
  - The Maximum CL
  - Elevation/Azimuth of the Max CL Detection
  - Extents of the cloud in Elevation and Azimuth
  - CL at Elevation/Azimuths of interest

What is CL (in simulation)

- Path integrated concentration aka concentration pathlength (CL)
- C – average concentration along pathlength
- L – length along the sensor field of view that represents the distance across the cloud



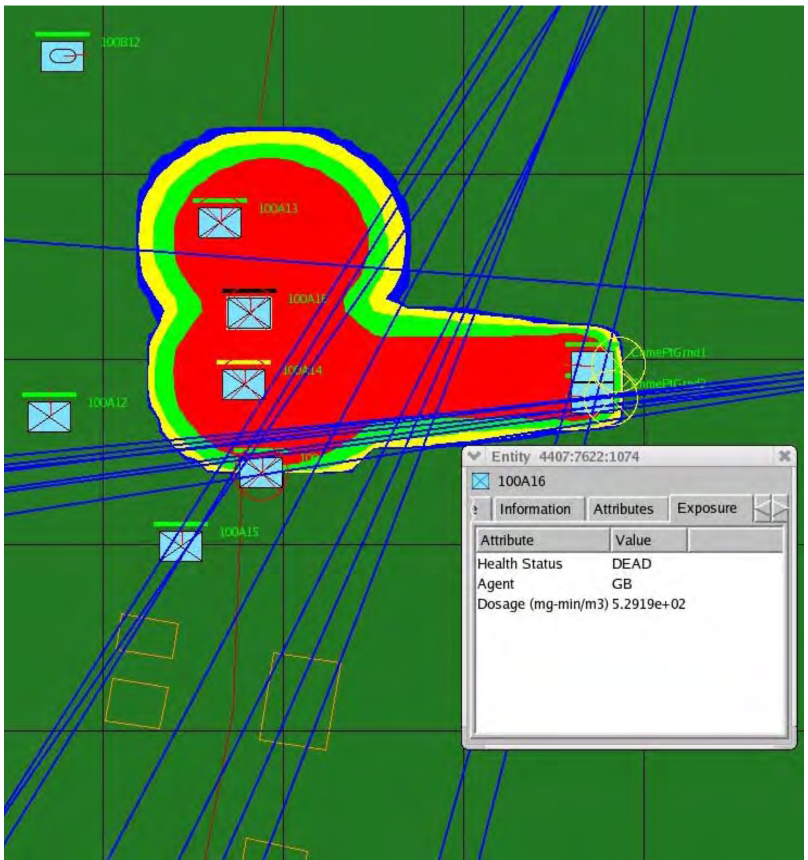
$$CL = \int_L C dl \ \ \textbf{(mg/m}^2\textbf{)}$$

Reference: Visualization of Foreign Gases in Atmospheric Air, Gruber Jr. , *et al.*, 11th International Symposium of Flow Visualization

CB Dial-A-Sensor

- Simulation tool (architecture) for representing any general technology class of CB particle and vapor sensors
  - Point and stand-off
  - Active and passive systems
- Capability to “dial” parameters to set performance characteristics for a known set of detector technology families
- Multiple data output mechanisms
  - Provide data to constructive simulations via DIS/HLA
  - Write data to a local file for analysis
  - Stimulate other system/operator software
    - Sensor user I/F
    - C2 messages

Exposure Toxicity Server



- Scalable methodology/tool for contamination and exposure tracking to support constructive simulation entity level simulation
- Selectable fidelity/methodology for human effects/lethality modeling
- Track effects status of entities in simulation

Exposure Toxicity Server

- Design Approach
  - Uses community accepted toxicity/lethality methodologies
    - Grotte/Yang
  - Allows user to select specific implementation (equation)

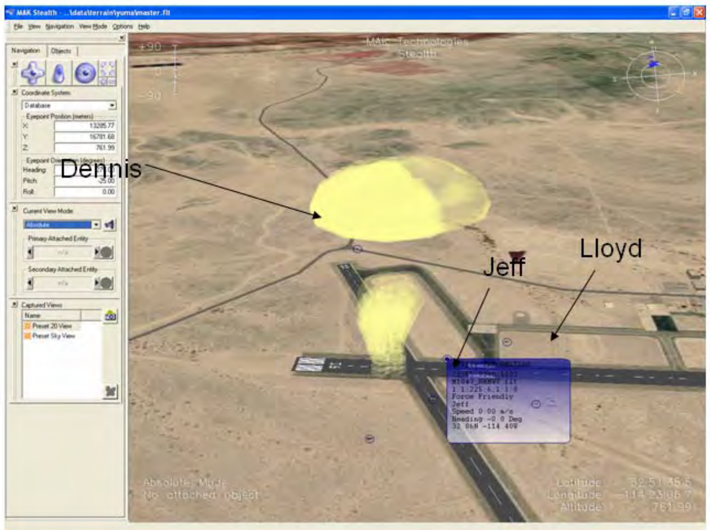
$$Y = b_o + b_1 \log(C) + b_2 \log(t) \quad [8]$$

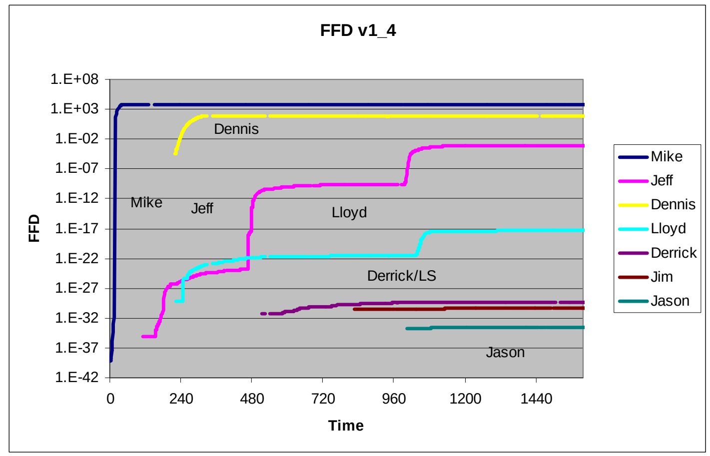
$$Y = b_o + b_2 \log(C^n t) = b_0 + b_2 \log(L1) \quad [9]$$

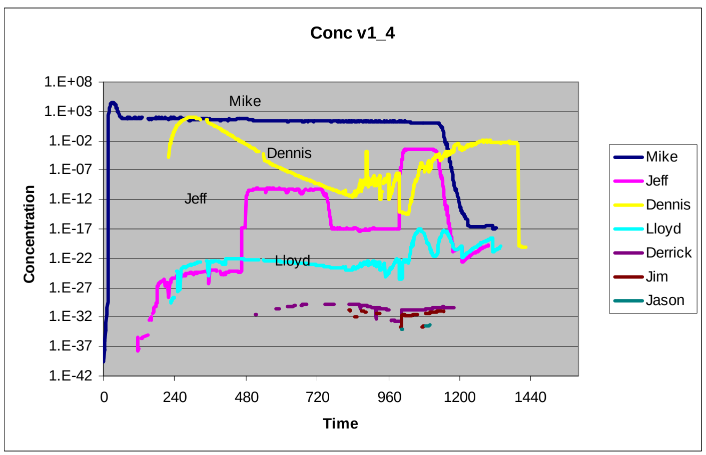
$$Y = b_o + b_1 \log(C t^{1/n}) = b_0 + b_1 \log(L2) \quad [10]$$

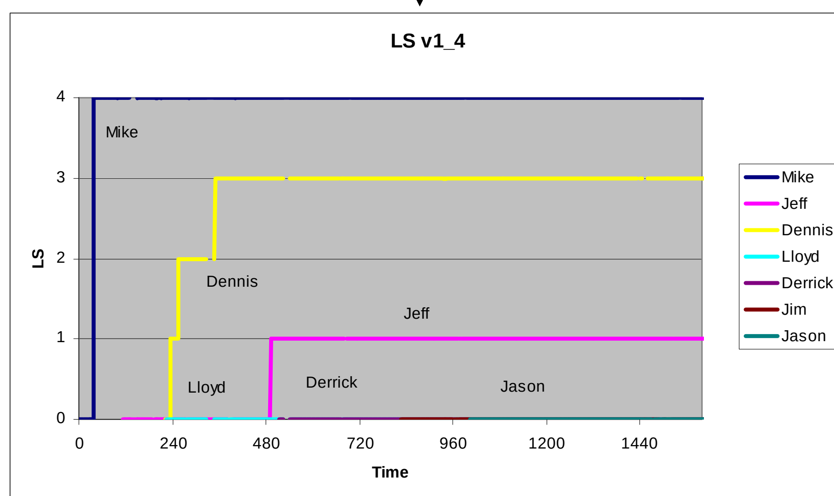
- Leverages/reuses CB Dial-A-Sensor infrastructure for exposure calculation, entity tracking and subscription

ETS Exposure Calculations









A Web-Based Knowledge Exploitation Toolset for the CBDP

Gaylen W. Drapé
Program Manager
ENSCO, Inc.

Chemical Biological Information Systems Conference
Austin, TX

January 10, 2007

Outline

- Motivation for Knowledge Exploitation Tools
- Conceptual Architecture / Process
- Software Technology Demonstration
- Potential Use Cases
- Implementation Issues
- Summary

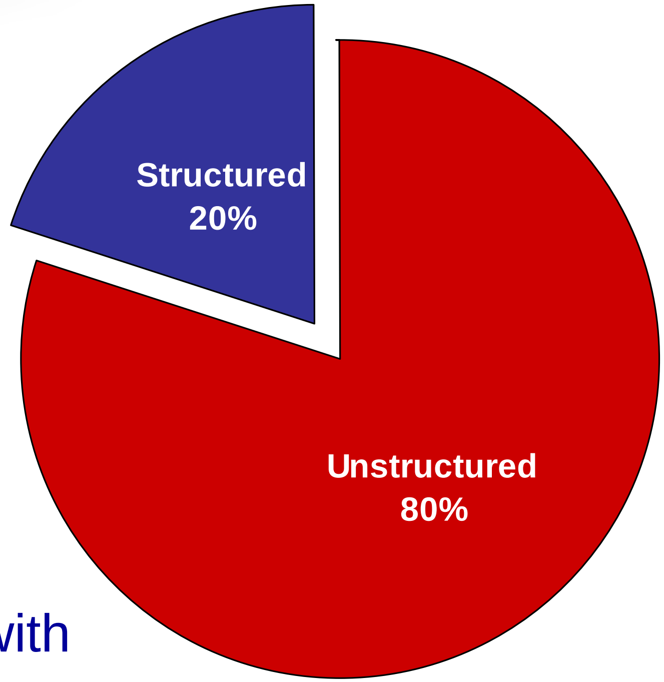
Challenges to Effective CBDP Decision Making

- Multiple participant organizations (government, industry, academia)
- Large volume of data stored in multiple formats and schemas
- Different business processes inherently require different kinds of information
  - S&T development
  - Product development
  - Testing and evaluation
  - Field O&M
- Inconsistent semantic standards increase difficulty of searching, analyzing, and adding to the body of knowledge

Need tools to grow and manage a complex knowledge base

Exploitation of Unstructured Information

- Structured data
  - Rows, columns, tables
  - Relationships predetermined
  - Tells the user “what”
- Unstructured content
  - Text, images, media
  - Structure can be discovered
  - Tells the user “how” and “why”
- Most business processes conducted with unstructured information (see right)



Source: Gartner Group

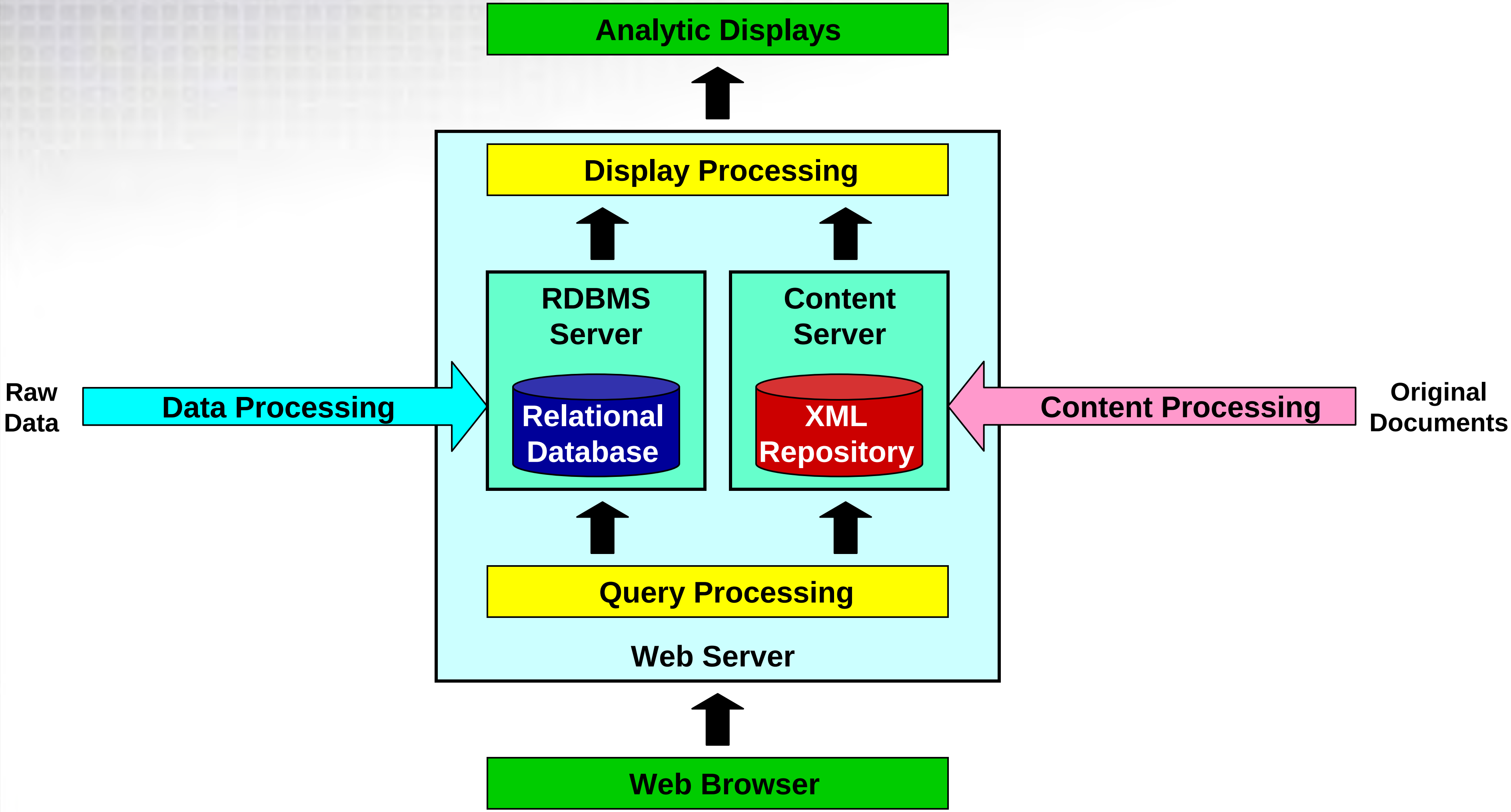
Exploitation of unstructured content is a huge opportunity

Technology Illustration: Biological Knowledge Base

- BioKB was a BAA project funded by DIA and DTRA
- Developed prototype biological data portal for MASINT and Biodefense communities
- Software built with Government-furnished data and content (~1 GB) from multiple sources (see below)

Structured *	**Unstructured ****
Bioassay protocols Project descriptions	Assay procedures Project deliverable docs Detector market survey DNA Purification survey S&T background info
* spreadsheets	** documents (Web, Word, .pdf, hard copy)

Conceptual Architecture / Processing



Software Demonstration

Biological Knowledge Base Prototype
Unclassified demo: https://www.biokb.ensco.com

For access, contact: Sandra Mahl – mahl.sandy@ensco.com
(321) 775-7547

Login Page - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://mb-demo/biokb/login.jsp

Getting Started Latest Headlines BIOKB

Biological Knowledge Base

Home | Contact Us

Sign-In

User Name:

Password:

New User? Login

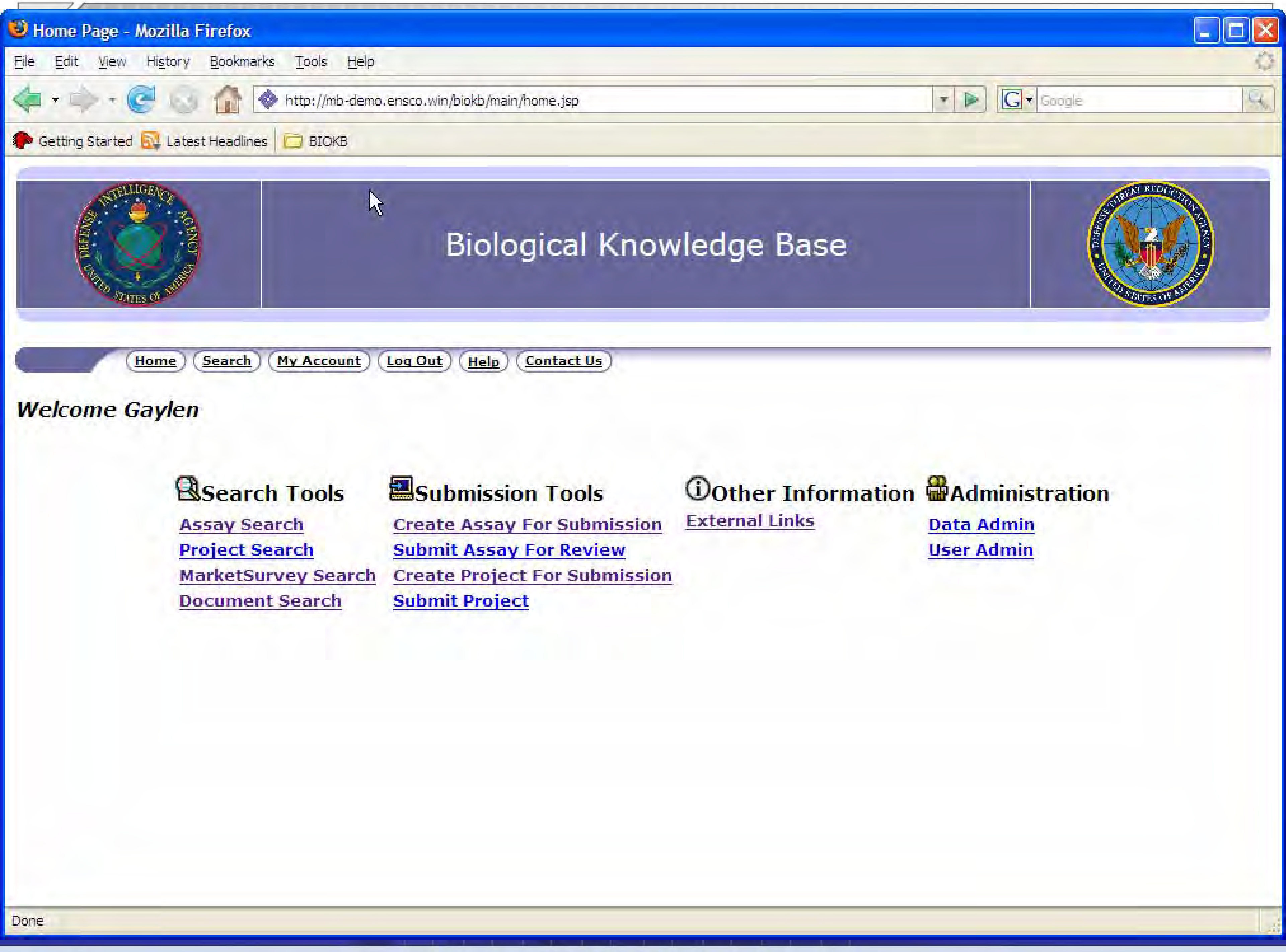
Forgot UserName/Password?

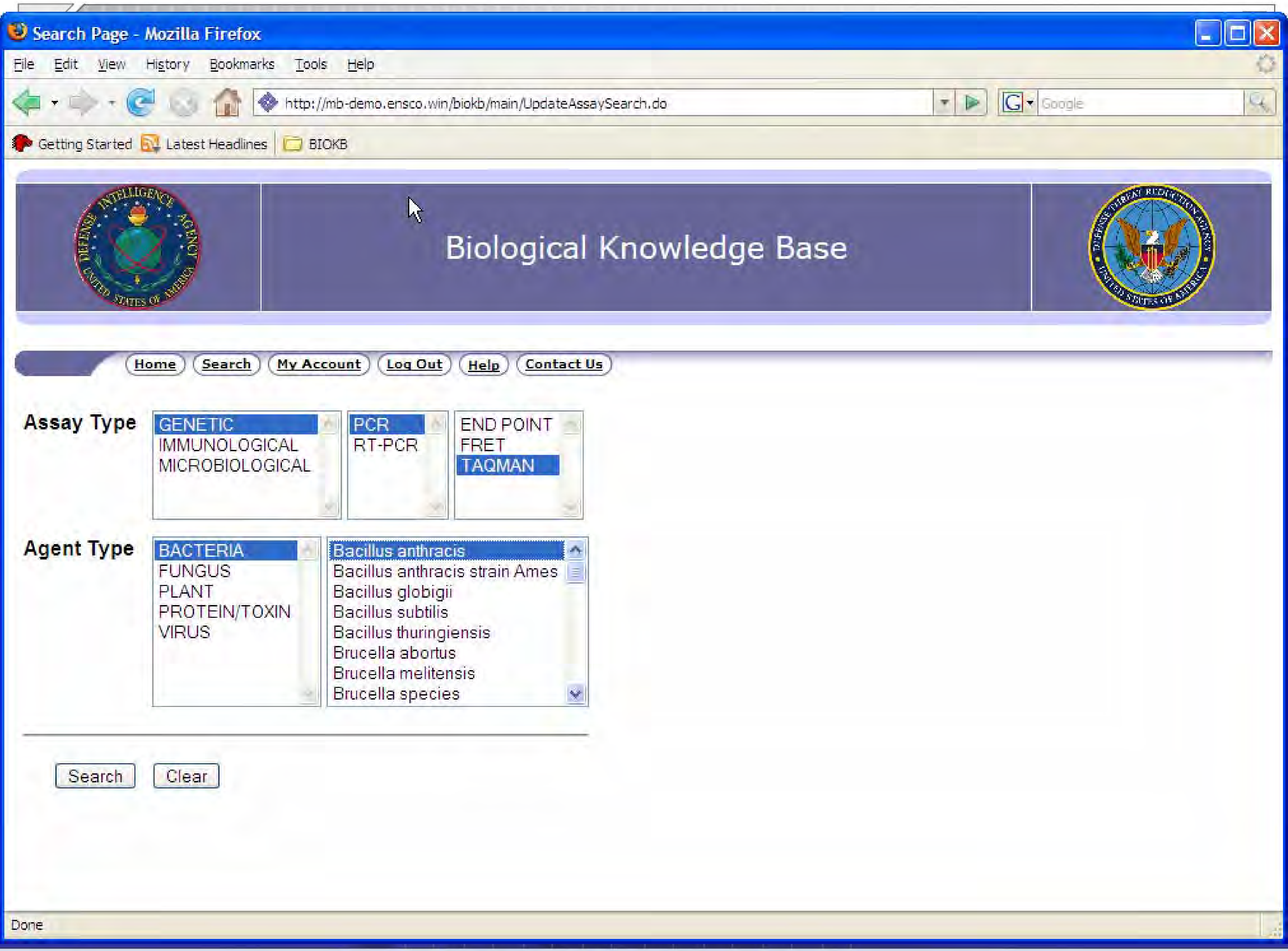
About Us

The MASINT/Biodefense System Evaluation Program (M/BSEP) grew out of a need for a searchable database for information to be shared across the MASINT and Biodefense communities. This database was initially populated with PCR assays, and has now expanded to include R&D project information and other information of interest to program managers, scientists, analysts, and others working in biology. The goal is to organize in a searchable form information submitted by any member of the community. The end objective of storing and organizing this information is to help reduce duplication of effort, facilitate coordination of projects, optimize return on efforts, identify overlaps and gaps, benefit from lessons learned, and improve our ability to leverage and collaborate with other government organizations.

DIA/DTT-1

Done


Home Page - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://mb-demo.ensco.win/biokb/main/home.jsp
Google
Getting Started Latest Headlines BIOKB
DEFENSE INTELLIGENCE AGENCY UNITED STATES OF AMERICA
Biological Knowledge Base
DEFENSE THREAT REDUCTION AGENCY UNITED STATES OF AMERICA
Home Search My Account Log Out Help Contact Us
Welcome Gaylen
Search Tools
Assay Search
Project Search
MarketSurvey Search
Document Search
Submission Tools
Create Assay For Submission
Submit Assay For Review
Create Project For Submission
Submit Project
Other Information
External Links
Administration
Data Admin
User Admin
Done


Search Page - Mozilla Firefox
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http://mb-demo.ensco.win/biokb/main/UpdateAssaySearch.do
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Assay Type
GENETIC
IMMUNOLOGICAL
MICROBIOLOGICAL
PCR
RT-PCR
END POINT
FRET
TAQMAN
Agent Type
BACTERIA
FUNGUS
PLANT
PROTEIN/TOXIN
VIRUS
Bacillus anthracis
Bacillus anthracis strain Ames
Bacillus globigii
Bacillus subtilis
Bacillus thuringiensis
Brucella abortus
Brucella melitensis
Brucella species
Search
Clear
Done

Search Results - Mozilla Firefox

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http://mb-demo.ensco.win/biokb/main/UpdateAssaySearch.do

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Search results for: Assay Type: GENETIC and PCR and TAQMAN and Agent Type: BACTERIA and Agent Name: Bacillus anthracis

Assay ID	Agent Name	Type	POC	Detection Limit	Instrument	Target Gene	Amplicon Length	Last Modified
6	Bacillus anthracis	GENETIC, PCR, TAQMAN	John Doe	100.0 fg	R.A.P.I.D Light Cycler	capA	89.0	2005-02-23
7	Bacillus anthracis	GENETIC, PCR, TAQMAN	John Doe	50.0 fg	R.A.P.I.D Light Cycler	capB	84.0	2005-02-23

New Search

Done

Detailed Data Sheet - Mozilla Firefox

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http://mb-demo.ensco.win/biokb/main/DetailSheet.do?assayid=6&orgid=4

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Return to Search Results

Oligo Summary for PCR Primer Set # 1

Sequence Type	Melting Temp(°C)	Stock Concentration	Final Concentration	Volume (µL)	Sequence	Length(bases)
Primer A	58.3	0.0 nM	0.0 nM	0.0	CTAGCTAGCTAGCTAGCTAGCTAG	20
Primer A	58.4	0.0 nM	0.0 nM	0.0	CTAGCTAGCTAGCTAGCTAGCTAG	20
Primer B	68.3	0.0 nM	0.0 nM	0.0	CTAGCTAGCTAGCTAGCTAGCTAG	20

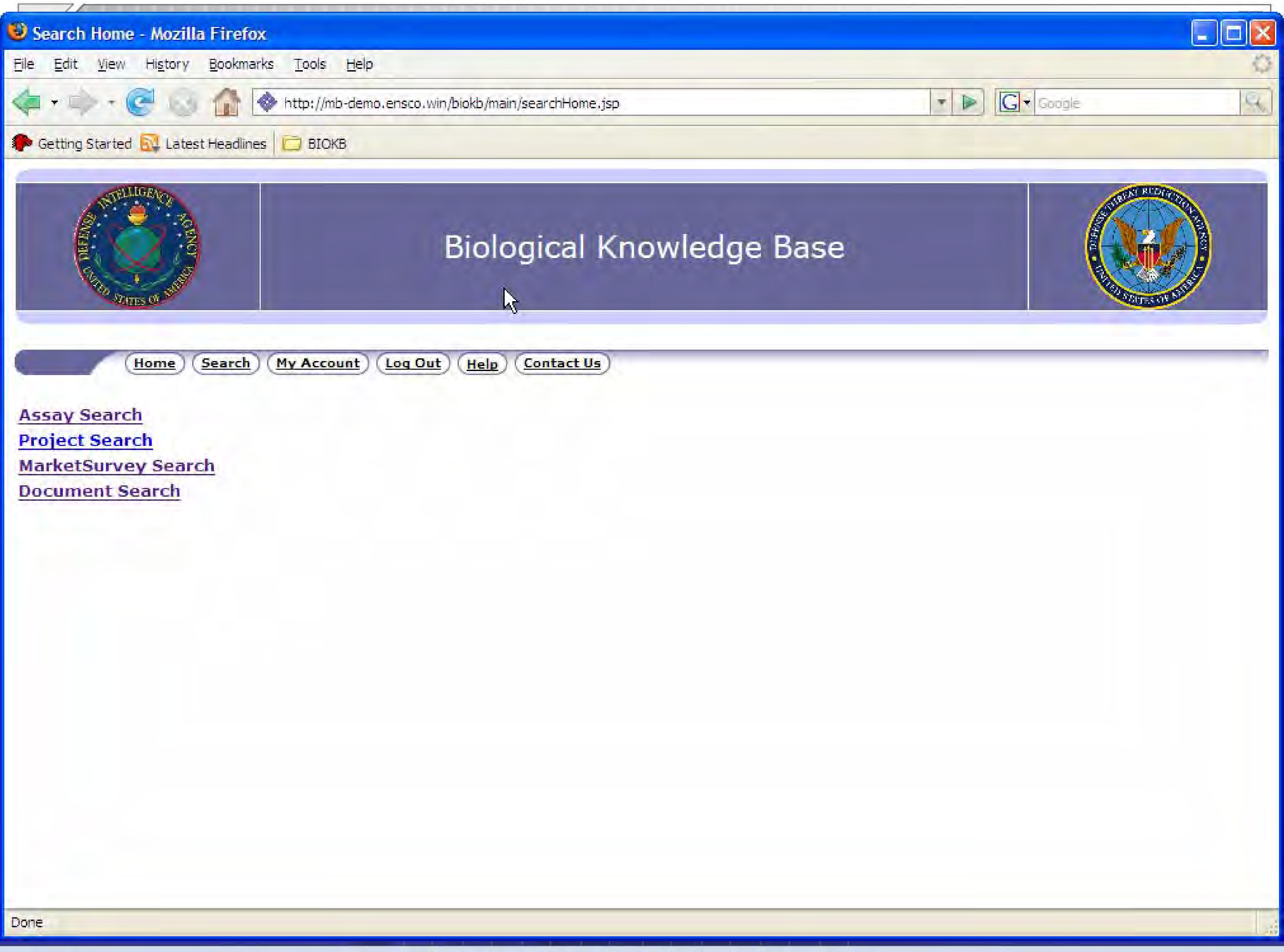
Primer #	Amplicon Length (bp)	Detection Limit	Gene	Agent
1	89.0	100.0 fg	capA	Bacillus anthracis of type BACTERIA

Instrument - R.A.P.I.D Light Cycler (PCR)

Reaction Conditions

Component Name	Source	Type	Volume (µL)	Stock Concentration	Final Concentration

Done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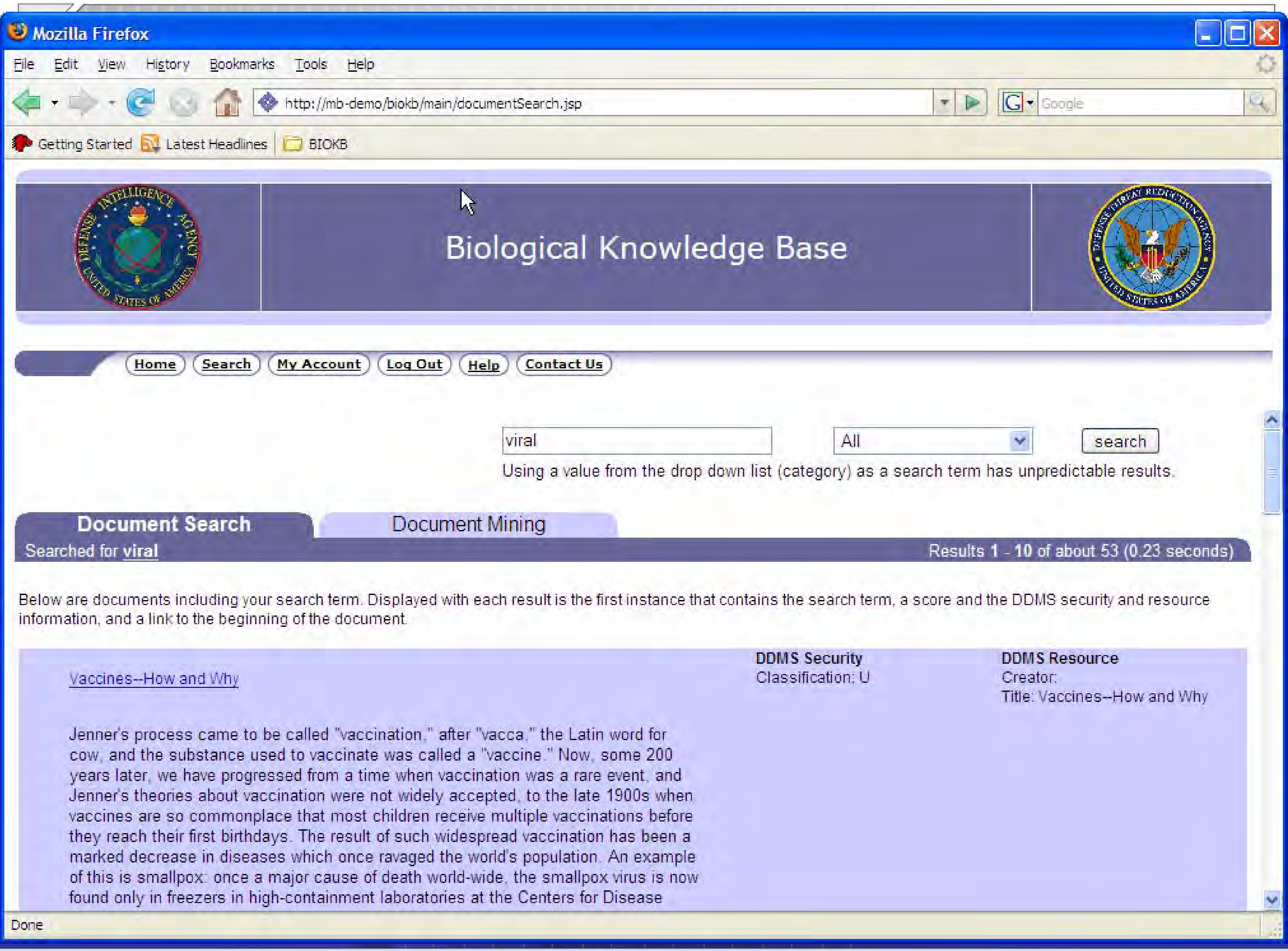
Assay Search
Project Search
MarketSurvey Search
Document Search
Done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viral
All
search
Using a value from the drop down list (category) as a search term has unpredictable results.
Document Search
Document Mining
Searched for viral
Results 1 - 10 of about 53 (0.23 seconds)
Below are documents including your search term. Displayed with each result is the first instance that contains the search term, a score and the DDMS security and resource information, and a link to the beginning of the document.
Vaccines--How and Why
DDMS Security
Classification: U
DDMS Resource
Creator:
Title: Vaccines--How and Why
Jenner's process came to be called "vaccination," after "vacca," the Latin word for cow, and the substance used to vaccinate was called a "vaccine." Now, some 200 years later, we have progressed from a time when vaccination was a rare event, and Jenner's theories about vaccination were not widely accepted, to the late 1900s when vaccines are so commonplace that most children receive multiple vaccinations before they reach their first birthdays. The result of such widespread vaccination has been a marked decrease in diseases which once ravaged the world's population. An example of this is smallpox: once a major cause of death world-wide, the smallpox virus is now found only in freezers in high-containment laboratories at the Centers for Disease
Done

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viral | technologies | search

Using a value from the drop down list (category) as a search term has unpredictable results.

Document Search | Document Mining

Searched for **viral** Results **1** - **1** of 1 (0.2 seconds)

Below are documents including your search term. Displayed with each result is the first instance that contains the search term, a score and the DDMS security and resource information, and a link to the beginning of the document.

Vaccines--How and Why

Jenner's process came to be called "vaccination," after "vacca," the Latin word for cow, and the substance used to vaccinate was called a "vaccine." Now, some 200 years later, we have progressed from a time when vaccination was a rare event, and Jenner's theories about vaccination were not widely accepted, to the late 1900s when vaccines are so commonplace that most children receive multiple vaccinations before they reach their first birthdays. The result of such widespread vaccination has been a marked decrease in diseases which once ravaged the world's population. An example of this is smallpox: once a major cause of death world-wide, the smallpox virus is now found only in freezers in high-containment laboratories at the Centers for Disease

DDMS Security
Classification: U

DDMS Resource
Creator:
Title: Vaccines--How and Why

Done

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viral | technologies | search

Using a value from the drop down list (category) as a search term has unpredictable results.

Document Search | **Document Mining**

Searched for **viral** — Results **1** - **4** of 4 (0.17 seconds)

Each document has been mined for the query term entered. All paragraphs containing the search are displayed.

Document: **Vaccines--How and Why**

fragment 1

DDMS Security
Classification: U

DDMS Resource
Creator:
Title: Vaccines--How and Why

Jenner's process came to be called "vaccination," after "vacca," the Latin word for cow, and the substance used to vaccinate was called a "vaccine." Now, some 200 years later, we have progressed from a time when vaccination was a rare event, and Jenner's theories about vaccination were not widely accepted, to the late 1900s when vaccines are so commonplace that most children receive multiple vaccinations before they reach their first birthdays. The result of such widespread vaccination has been a marked decrease in diseases which once ravaged the world's population. An example of this is smallpox: once a major cause of death world-wide, the smallpox virus is now found only in freezers in high-containment laboratories at the Centers for Disease

Done

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fragment 2

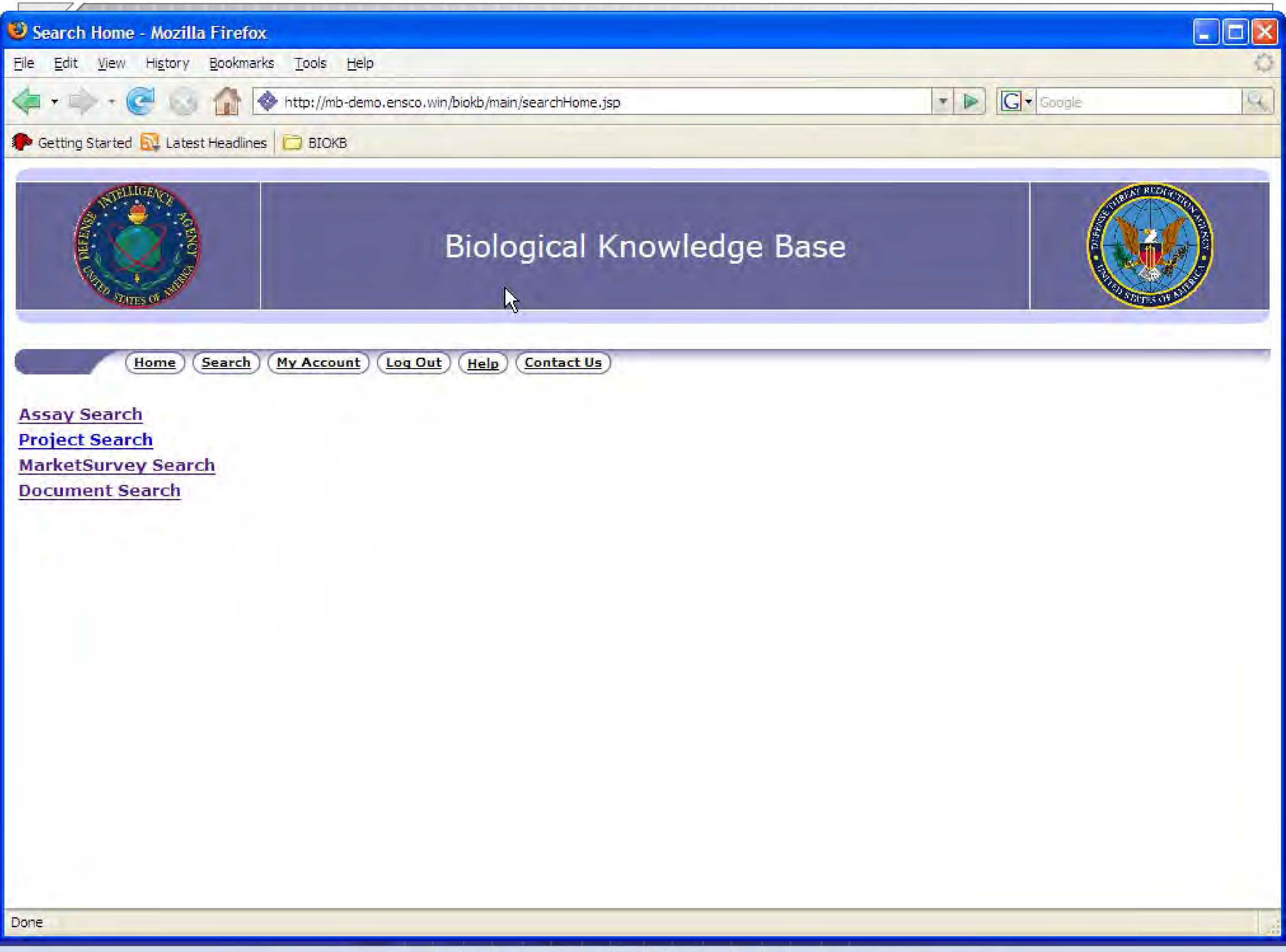
Classification: U

Creator:
Title: Vaccines--How and Why

Disease causing organisms have at least two distinct effects on the body. The first effect is very obvious: we feel sick, exhibiting symptoms such as fever, nausea, vomiting, diarrhea, rash, and many others. Although the second effect is less obvious, it is this effect that generally leads to eventual recovery from the infection: the disease causing organism induces an immune response in the infected host. As the response increases in strength over time, the **infectious agents** are slowly reduced in number until symptoms disappear and recovery is complete.

How does induction of the immune response occur? The disease causing organisms contain proteins called "antigens" which stimulate the immune response. The resulting immune response is multi-fold and includes the synthesis of proteins called "antibodies." These proteins bind to the disease causing organisms and lead to their eventual destruction. In addition, "memory cells" are produced in an immune response. These are cells which remain in the blood stream, sometimes for the life span of the host, ready to mount a quick protective immune response against subsequent infections with the particular disease causing agent which induced their production. If such an infection were to occur, the memory cells would respond so quickly that the resulting immune response could inactivate the disease causing agents, and symptoms would be prevented. This response is often so rapid that infection doesn't develop - you are immune from infection.

Done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Project Search
MarketSurvey Search
Document Search
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Market Survey Search

Name

Size: Approx the size of a carry-on luggage suitcase

Sensitivity

Signature

Re-Use

MarketSurvey Type: Detector

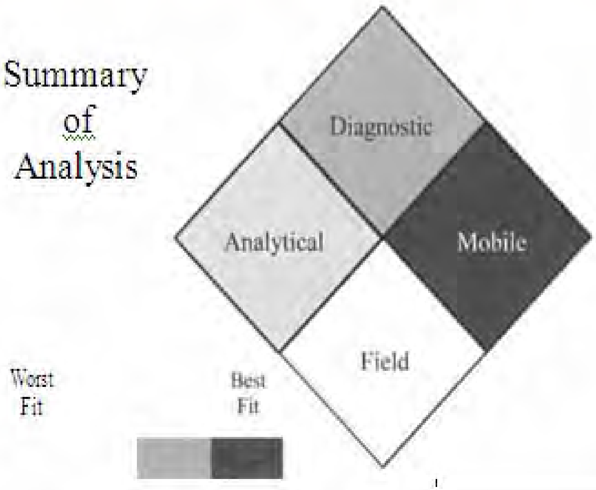
Submit Query

Name	Vendor	Size	Sensitivity	Signature	Re-Use
Eppendorf Mastercycler Step*	Eppendorf	Approximately the size of a carry- on luggage suitcase Between 5 and 25 kg Shelf life between 1 and 3 years	Unknown CFU per ml	No sounds produced that cannot be deactivated Between 200-500 BTUS generated	N/A
LD 400 Luminescence Detector	Beckman Coulter, Inc.	Approximately the size of a carry- on luggage suitcase Between 5 and 25 kg NA shelf life	N/A	N/A	Device or system is intended for multiple use NA solutions or buffers used 1 component Tubing cleaning required once a week

Done

detector_118-137-1.doc - Microsoft Word

Summary of Analysis



MatriCycler Evaluation Criteria Provided by Vendor

Sensitivity:
- NACFUperml

Maturity Gauge:
- A few devices or systems exist (brass board)

• O 0 O

Ease of use/Utility
- Cannot view results "in real time"
- NA centrifugation steps
- NA vortexing steps
- NA to interpret raw data or call a positive through internal software
- NA detecting multiple biological agents or toxins within the same test
- NA additional pieces of equipment needed
- NA sample purification

System requirements:
- System or device has 110V electrical requirement
- The system or device does not require water
- The system or device does not require an external air or gas source
- The system or device does not require an external vacuum source

Re-use:
- Device or system is intended for single use
- NA solution or butler used
- NA components
- NA cleaning

Maintenance:

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Sign-In

User Name:

Password:

New User? Login

Forgot UserName/Password?

About Us

The MASINT/Biodefense System Evaluation Program (M/BSEP) grew out of a need for a searchable database for information to be shared across the MASINT and Biodefense communities. This database was initially populated with PCR assays, and has now expanded to include R&D project information and other information of interest to program managers, scientists, analysts, and others working in biology. The goal is to organize in a searchable form information submitted by any member of the community. The end objective of storing and organizing this information is to help reduce duplication of effort, facilitate coordination of projects, optimize return on efforts, identify overlaps and gaps, benefit from lessons learned, and improve our ability to leverage and collaborate with other government organizations.

DIA/DTT-1

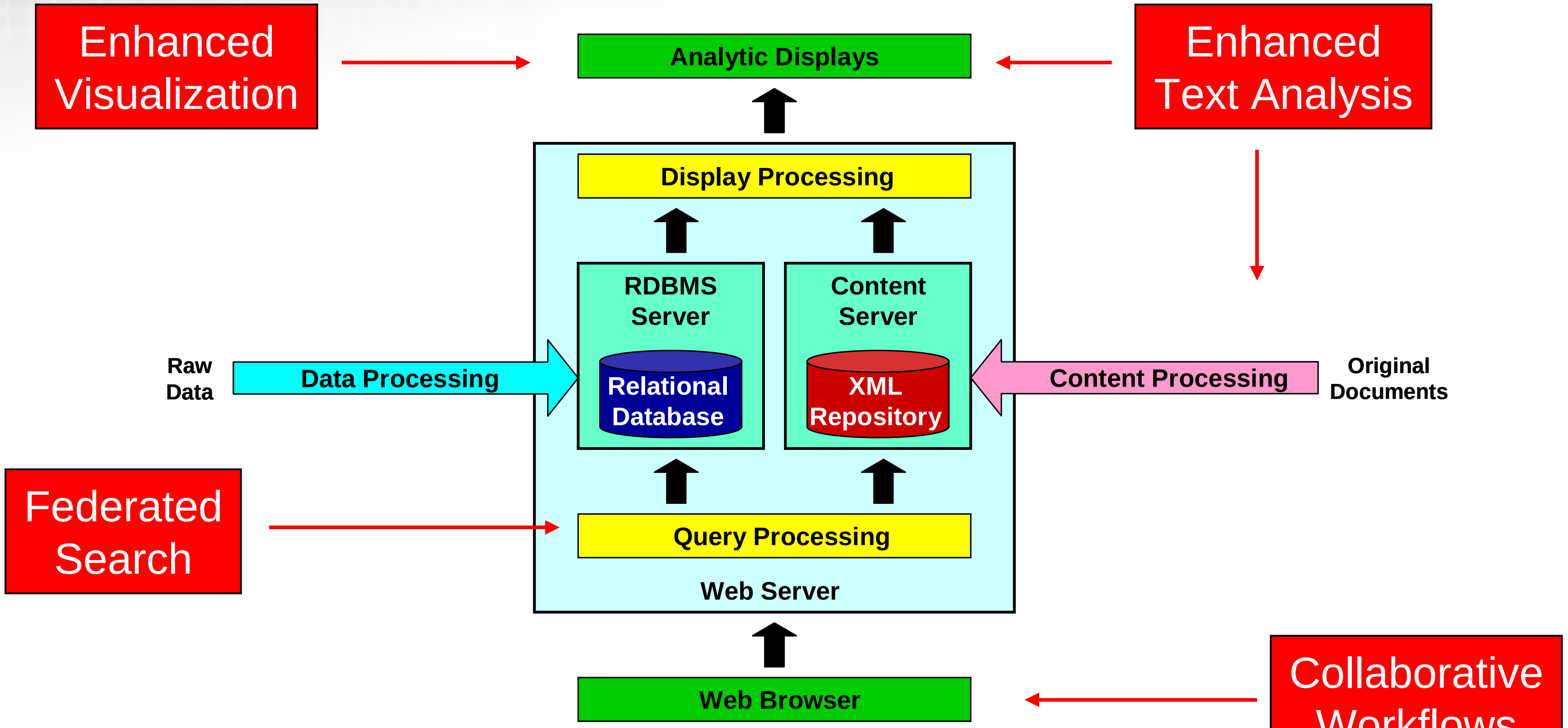
Done

End of Demonstration

Business Cases for Unstructured Content Analysis

- Detector Capability Assessment
  - Issue: Difficult to compare and evaluate detector characteristics across multiple dimensions
  - Solution: Analysis of detector documentation, automatically summarize entities & concepts, route among SMEs for comment
  - Benefit: Accelerate creation/adoption of data standards, enable deeper understanding of capability and investment opportunities
- Test Traceability
  - Issue: Test plans & procedures not consistent with standards
  - Solution: Search/retrieve/parse content from existing test DB/documents, then map to elements of standard test process
  - Benefit: Facilitate creation of overarching T&E model for broader application of test data, more efficient use of resources

Potential Architecture Directions



Implementation Issues

Issues we encountered in the BioKB project:

- Accessibility of Documents via Government WANs
- Verification and Validation of input document content
- Certification and Accreditation of COTS technology components
- Organizational barriers to information sharing

Issues are both technical and non-technical in nature

Some ideas:

- Strong governance by Sponsor, e.g. steering group
- Partnership agreements among users/developers/integrators
- Provision of software test / demonstration network

Summary and Concluding Thoughts

- Opportunity for exploitation of unstructured data
  – Increase level of knowledge sharing across CBDP community
  – Answer "tough questions" to speed up development and transition
  – Reduced effort of CBD researchers and analysts
- Maturing industry standards and community-wide data integration make web-based KB tools feasible
- Broad-scale implementation a challenge for technical and non-technical reasons
- Suggest development of focused pilot KB applications to work out implementation issues, demonstrate ROI

Thank You!

Joint Project Manager Information Systems (JPM IS) Chief Engineer's Overview

"From Science and Technology (S&T) to the Field"

CBIS

January 2007

Dave Godso
Chief Engineer
JPM Information Systems
Joint Program Executive Office
for Chemical and Biological
david.godso@jpmis.mil

Agenda

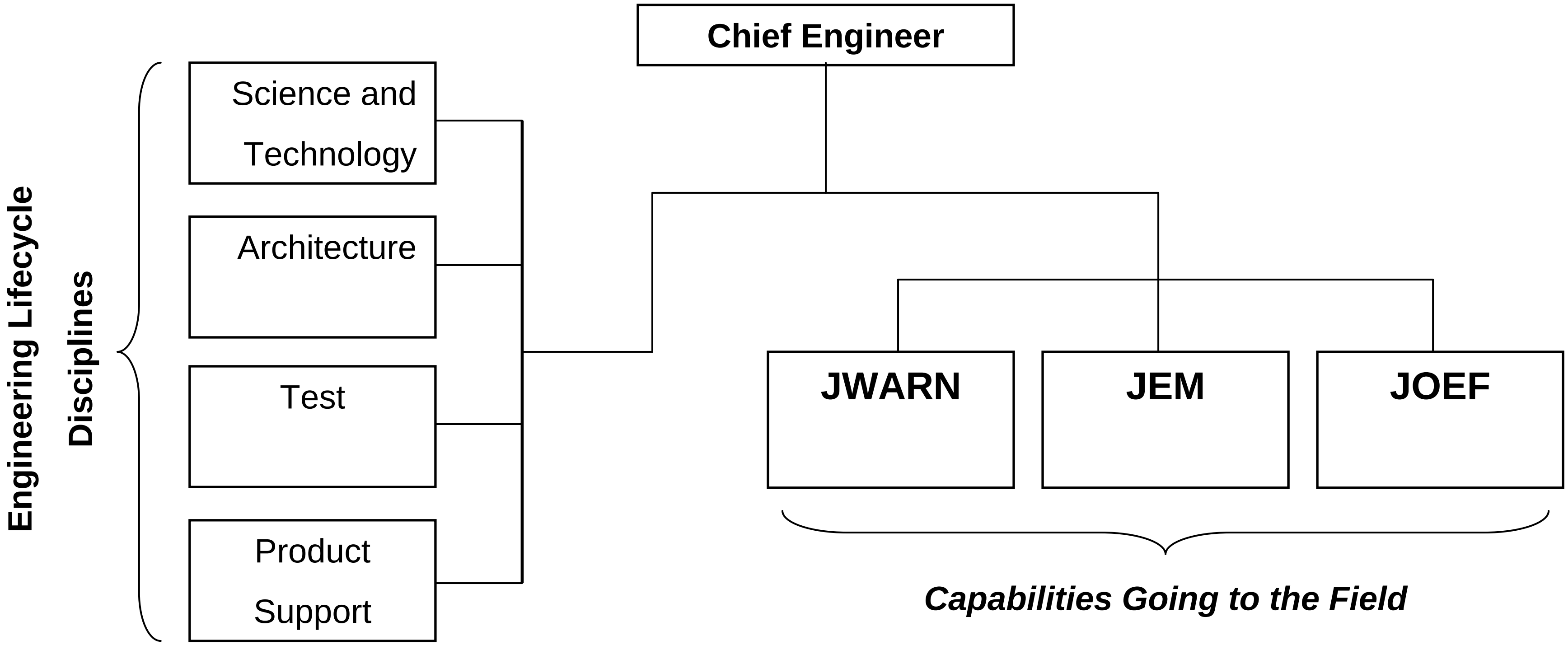
- Current Acquisition
- Techniques to Improve Transition Success
- Challenges and How We Address Them

Current Acquisition - Mission

Integrating CBRN Information Technology and capabilities with all Service C2/C4ISR systems, environments, and platforms, fielding those capabilities to the Warfighter and supporting the Warfighter

- Tactical to Strategic
- All DoD Military Services
- All Echelons
- Real-Time Response to Deliberate Planning
- One Stop Shop for DoD CBRN Information Technology Warfighter Capabilities

Current Acquisition - Organization



- **Science and Technology –**
  - **Mr. Les Anderson - make transition "tangible" / track / facilitate**
- **Architecture**
  - **Mr. Andy Hill – plan for transition (Architecture/Data, Human Systems Interfaces (HSI), Information Assurance (IA,) C2/C4ISR)**
- **Test**
  - **Mr. Marcus Fieger – are the transitioned products "VV&A"-ed and/or "VV&A"-able?**
- **Product Support**
  - **Mr. Gerald Slonaker – can we train to them and support them?**

Current Acquisition –
Two Points of Transition for CBRN Information Systems

1. From Science and Technology (S&T) to JPM IS

2. From JPM IS to the Field

- **WANT TO:**
  - Minimize cycle time to get required new capabilities and updates to existing capabilities to the Warfighter quickly and cost effectively
  - Insulate our technology from infrastructure change to the extent possible, so we can maximize the resources spent on CBRN capabilities (e.g. everyone should not be worried about web-services, security, content delivery, mediation, etc)
- **MUST:**
  - Standardize our engineering processes and environments to create a more effective cycle from S&T to JPM IS and from JPM IS to the Field (Warfighter)

Techniques for Improving Transition

- Common Installation Process / Specifications
  - Would like Tech Base to utilize JPM IS emergent product
  - Ability to "hook-in" your application/service installation
- Common Development Environment / Specifications
  - Need well-documented instructions and automated scripts to build and install software
    - Accurate and detailed software product / module specifications
    - Accurate and detailed software version descriptions and manifests
  - Alignment of development tools, languages, and environments to the extent possible and practical
  - Cost effective design and development tools
    - Maintenance is the most expensive part of the program lifecycle

Techniques for Improving Transition

- **Software Development Kits**
  - Same Architecture: Components / Modules / Service Oriented Architecture (SOA) / Protocols
  - Same Version of Data Model and Schema
  - JWARN - for Plug and Play (PnP) of Sensors and Information Systems Components [NOTE: tracking to Holster and JCID on a Chip Efforts, but should be based on current JWARN protocol]
  - JEM - for PnP of HD/HP models into the model harness architecture [First versions of SDK forthcoming.]
  - JOEF - for PnP of Consequence Management / Course of Action models and calculators into the JOEF architecture

Techniques for Improving Transition

- **Minimize intellectual property or restrictions on government use/modification and deployment of software, data, and documentation**
- **Horizontal Integration**
  - **Shared components across programs (SOA) implies TTAs will need to span more than one program of record**
  - **Acquisition strategy updates (Software Product Lines)**
- **Shared Configuration Management Repository between JS&TO and JPM IS**
- **Engage, write bug reports, track them to implementation and closure … JPM IS can always use more proactive eyes-on-product with feedback from the S&T community so we can improve our baseline and the feedback loop**

Challenges and How We Address Them

- **Our Field-target environments are always under development / evolution and pressure to field:**
  - FBCB2, C2PC, MCS, GCCS-J/-X, etc. [All different schedules.]
  - Relationships and agreements, one by one - we provide to all
- **Tracking to system/environment consolidation over time**
  - [FBCB2 => JCR/JBCP, FCS Platforms], [C2PC => JTCW], [GCCS-X => NECC], etc.
  - Day to day involvement and having a voice, vice reacting
- **DoD Fielding Alignment**
  - We are Joint but we must field to all four Services and their Service specific systems / hosts / environments (SoA)
  - Dedicated presence in the Army Software Blocking (ASWB)

Science & Technology Folks: If You want to know where we are going and when, look no further than the target environments and platforms to which we must field, mapped against the requirements of an "Increment" of a particular program.

Challenges and How We Address Them

- Silver-bullet mentality… “SOA”, “Web-Services”, “XML”, “Net-Centric”
  - Architecture, Data Management, Configuration Control
  - Stability & Control of Interfaces ("schemas“, APIs, etc.)
  - Don’t loose sight of basic good systems engineering practices and software design principles
- Provide different capabilities at all levels of echelon
  - Modular and configurable approach for services / software
  - Many agreements put in place with each Service target/platform
- Availability (horsepower, bandwidth, connectivity) –
  - Much of what we do in CBRN missions is at the tactical level
  - Meet net-centric enterprise tenants, but also work with the resources available at the tactical level
  - Parallelization and incremental calculations going forward

Challenges and How We Address Them

- **You're Done!**
  - **In software, if you are ever "done", then you must:**
    - **Be irrelevant**
    - **Be out of business**
    - **Have legacy code that will likely never change (e.g. RS-232 protocol)**
  - **Emerging technology, standards and greater DoD / DISA continue to change and we must always respond to that change to maintain compatibility and relevance and superior capability...**
  - **At JPM IS we want to build infrastructure which insulates us from changes to the extent possible, so we can focus resources on CBRN capabilities, but must still respond to all to which we field**

CBRN Information Technology is not Done… We're Just Getting Started… Our Relationship with the Tech Base is Critical to our success going forward!

Points of Contact

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Mr. Marcus Fieger, JPM IS Test Lead

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Mr. Gerald Slonaker, JPM IS Product Support Lead

gerald.slonaker@jpmis.mil

Using Experimentation to Support Future Capability Needs: CB Effects in the JFCOM Urban Resolve Experiment

Ian Griffiths, Andrew Solman, Neil Dyer – Dstl

Doug Brain – RiskAware

Mark Biwer – Northrop Grumman

Lt Col Mike Wall – DTRA

Overview

- Aim of M&S
- Capability
  - Real World Representation
  - Hazard Prediction Concept Demonstrator
- Applications
  - Training – JVTSE
  - Experimentation – Urban Resolve
- Summary and future plans

Aims of M&S

- Concept demonstration
- Training
- Experimentation
  – Evaluating effect on campaigns
  – Requirements definition
  – Balance of investment
- Raising technology readiness

Dstl's CBR M&S Capability

- The capability splits into two areas
  - Real-World Representation
    - Exists to stimulate Hazard Prediction Concept demonstrator and other systems
  - Hazard Prediction Concept Demonstrator
    - Allows demonstration and evaluation of emerging technologies
    - Exploration and clarification of requirements for future hazard prediction systems

Real-World Representation

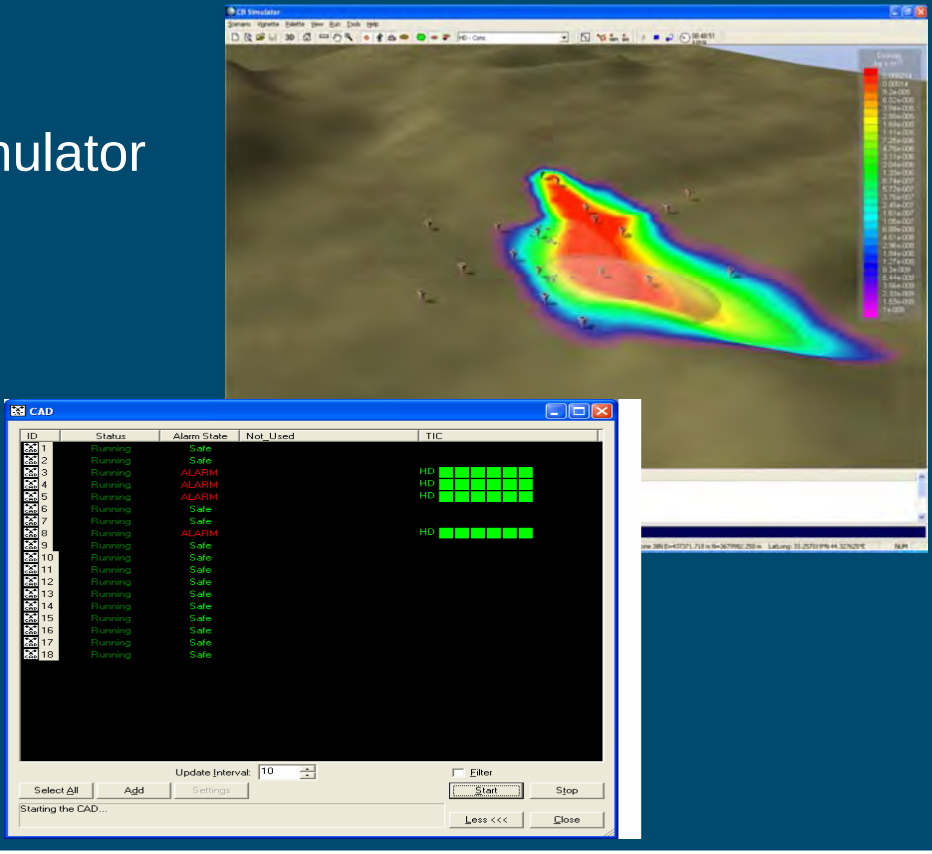
- Sophisticated CBR modelling used to
  - Simulate realistic ground truth
  - Stimulate other systems

Courtesy of RiskAware Ltd

Courtesy of RiskAware Ltd

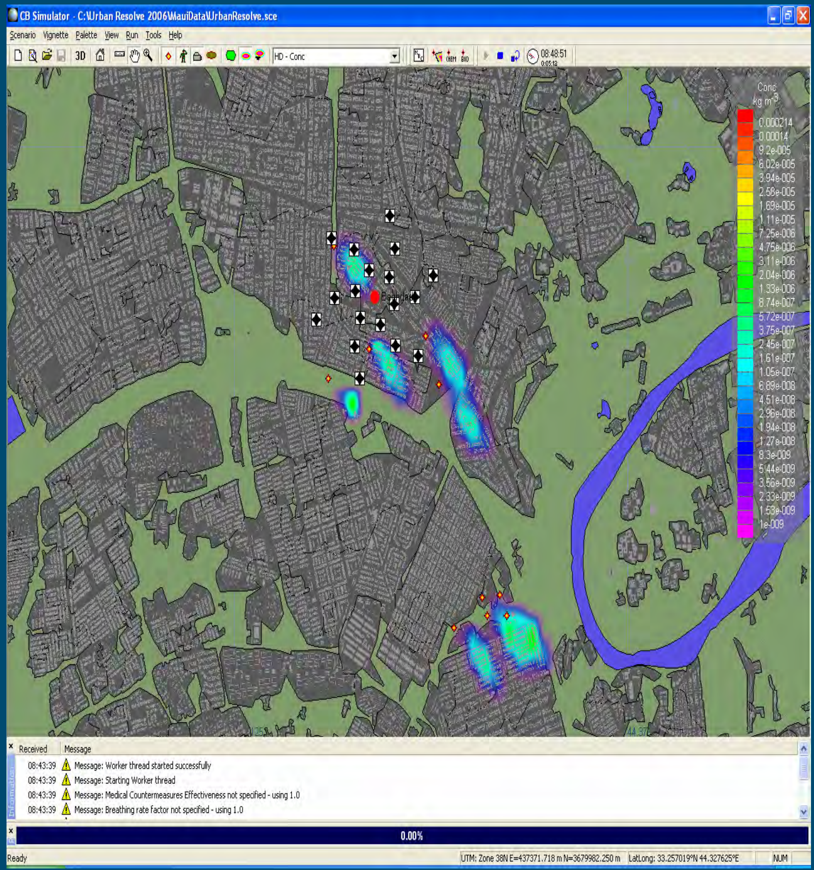
Real-World Representation

- The "Ground Truth" representation consists of the following elements
  - Chemical and Biological Simulator (CBSim)
  - Detector models
  - Ground-truth visualisation



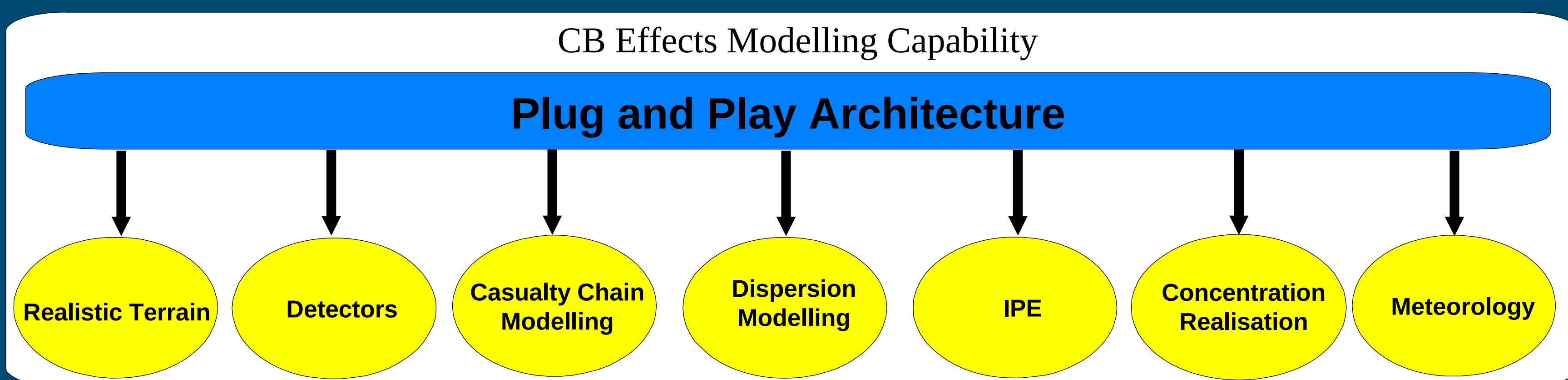
CBSim

- CBSim provides real-time modelling capability
  - Urban dispersion
  - Instantaneous dispersion realisation
    - Terrain effects
    - Meander effects
    - Concentration realisation
  - Stimulation of detectors
  - Casualty calculations



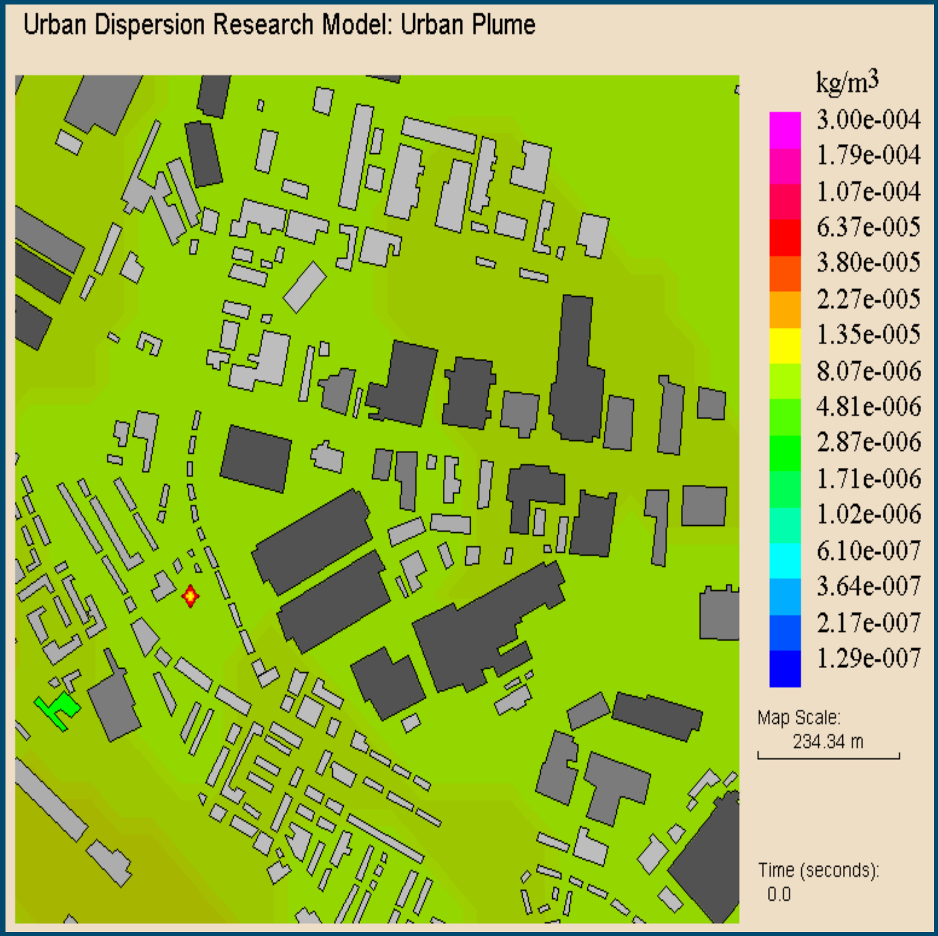
CB Effects Modelling Capability

- Dispersion Modelling
  - 2D and 3D CBRN sources and hazard plumes
- Terrain
  - FACTS, Meander, Buildings
- Meteorology
- Value of Information
- Detectors
  - Chemical, Biological, Bio Background
- Casualty Chain Modelling
- Effects of Hazards
  - IPE
- Concentration Realisation
- Aggregated Entities



Dispersion Modelling - The UDM

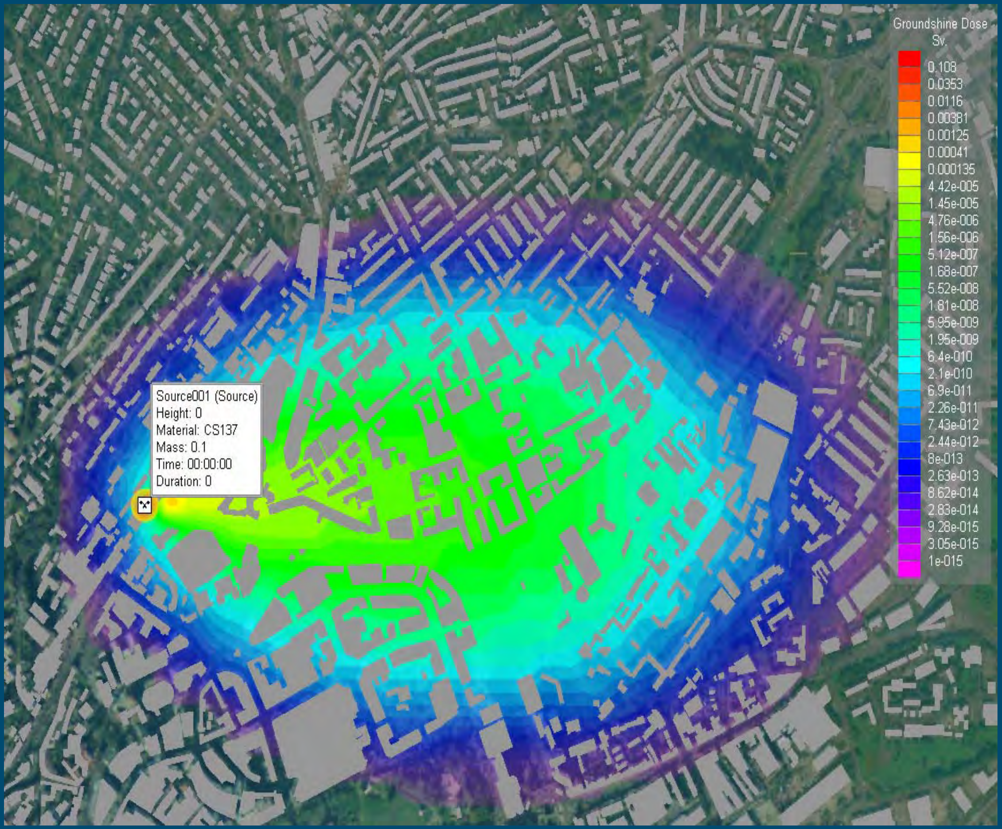
- Runs in
  - Real-time
  - Instantaneous mode
    - Different to ensemble hazard, e.g. HPAC, JEM
    - Gives a single realisation
- Uses updating wind input



CBR Plume Output

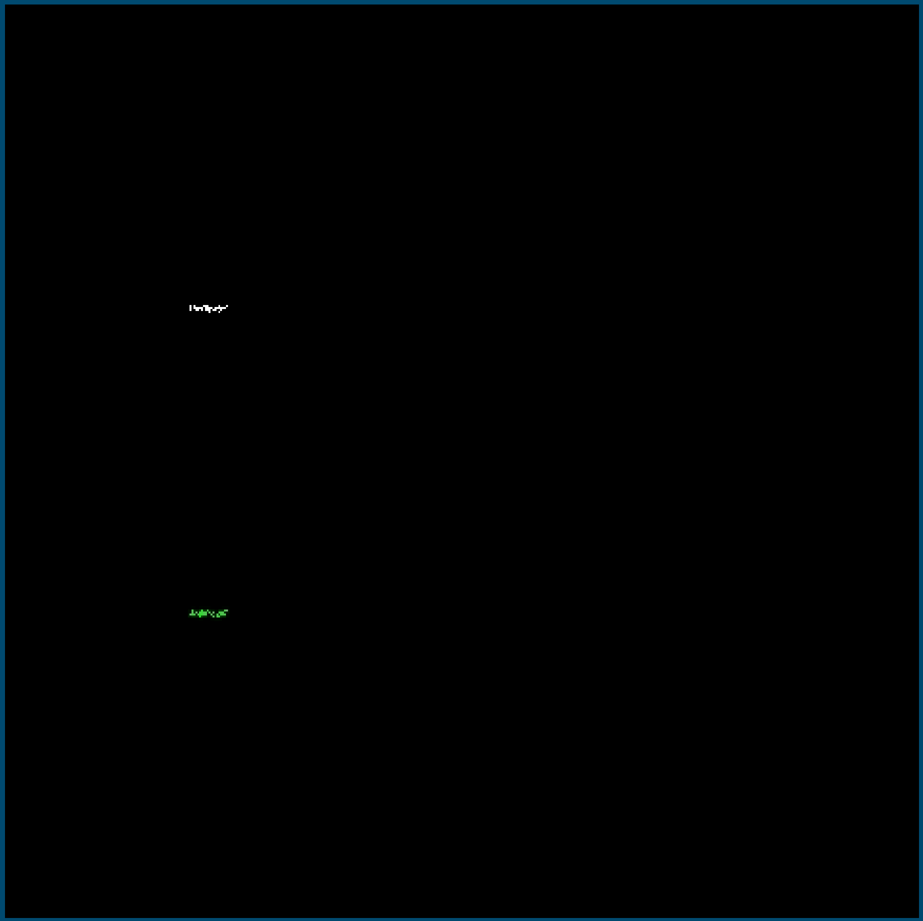
- Output of CB material plumes
  - Dosage
  - Deposition
  - Concentration
- Radiological material plumes
  - Cloud and ground shine
  - Energy deposited in tissues
  - Also inhaled dose

Ground shine 1 minute after a 190kg release of Cesium 137



Realistic Meteorology modelling

- Meander Model
- AERMET boundary layer model
- Empirical sea breeze model
- Linear model of flow over hills
- Slope flow model



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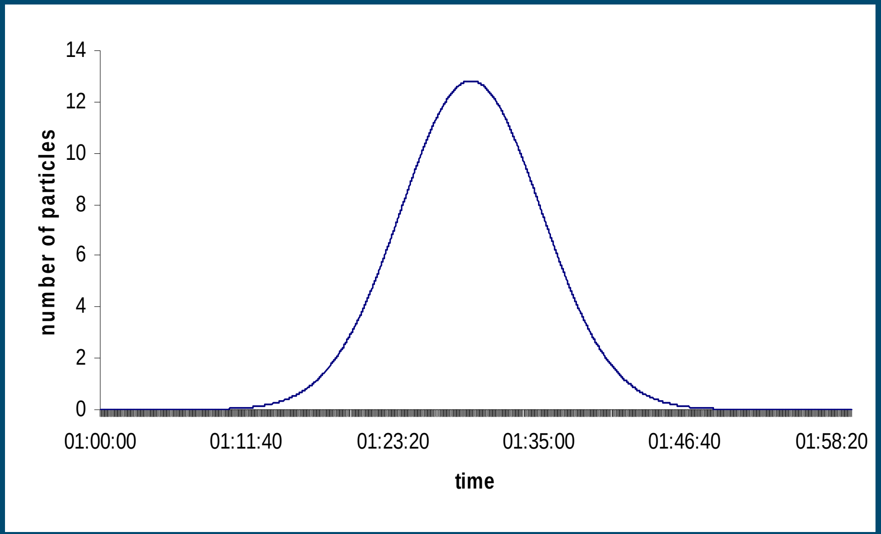
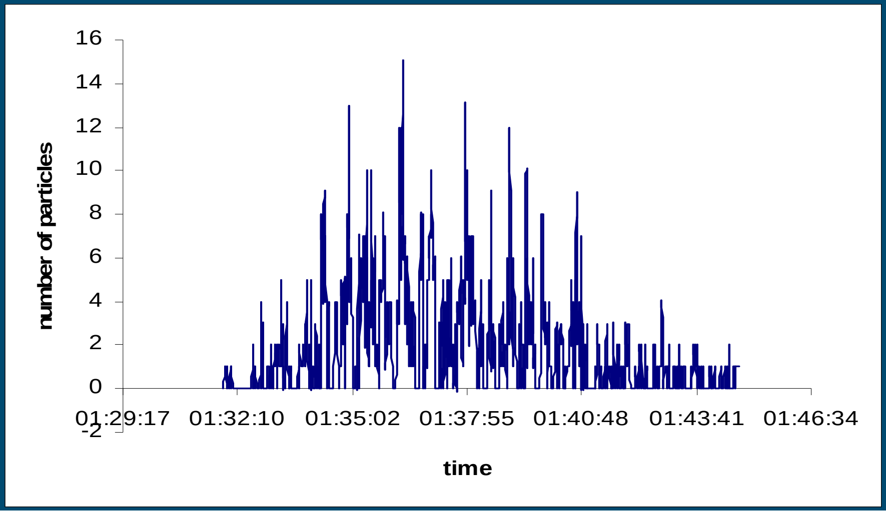
Dstl is part of the Ministry of Defence

Generating realistic time series

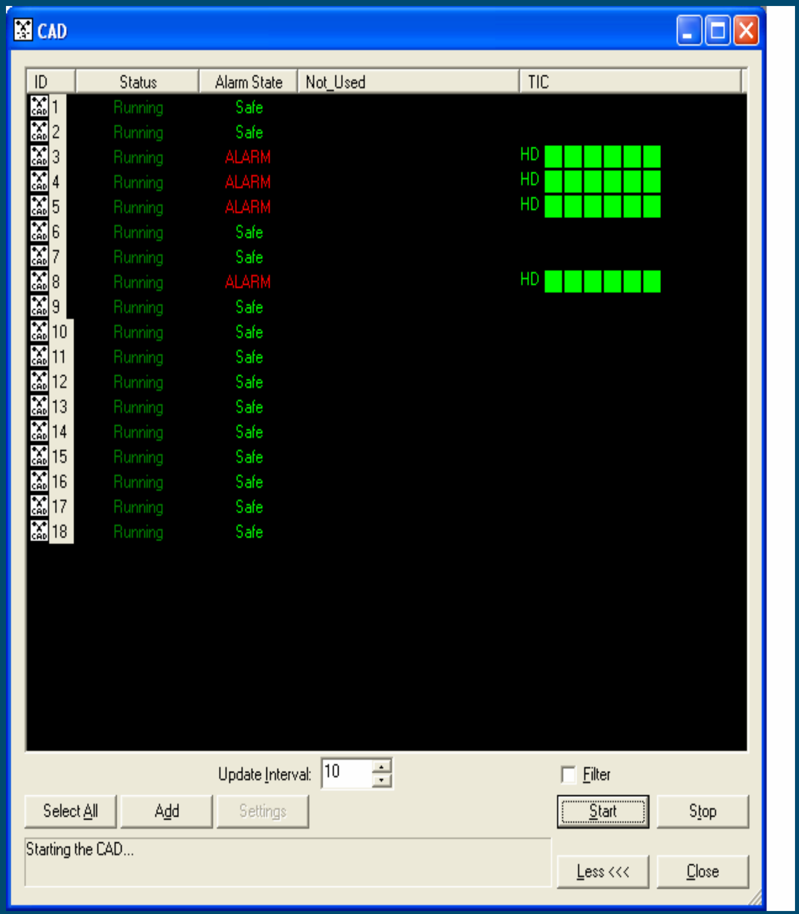
- Concentration of challenge at detector calculated by UDM driven by large scale meandering winds
- Concentration realisation agent used to generate realistic time series
  - Simulates turbulent variations in concentration within puff
- Particles then sampled from this time series with noise





Detector models

- Configurable chemical detector models
- Bar based detector
- Alarms at a threshold
- Challenged by realisation of concentration



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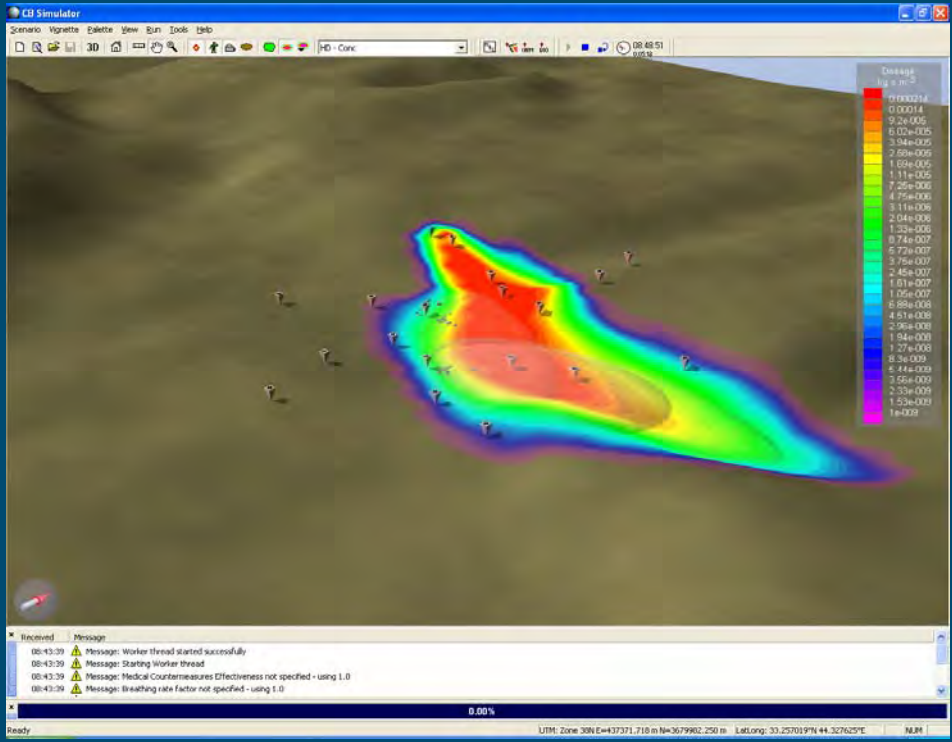
Ground Truth Visualization

- 2D/3D representation
  - Buildings
  - Terrain
  - Dosage, concentration, effects contours
  - Puffs
  - Detectors/entities
- Visualiser can be distributed from CBSim calculation core

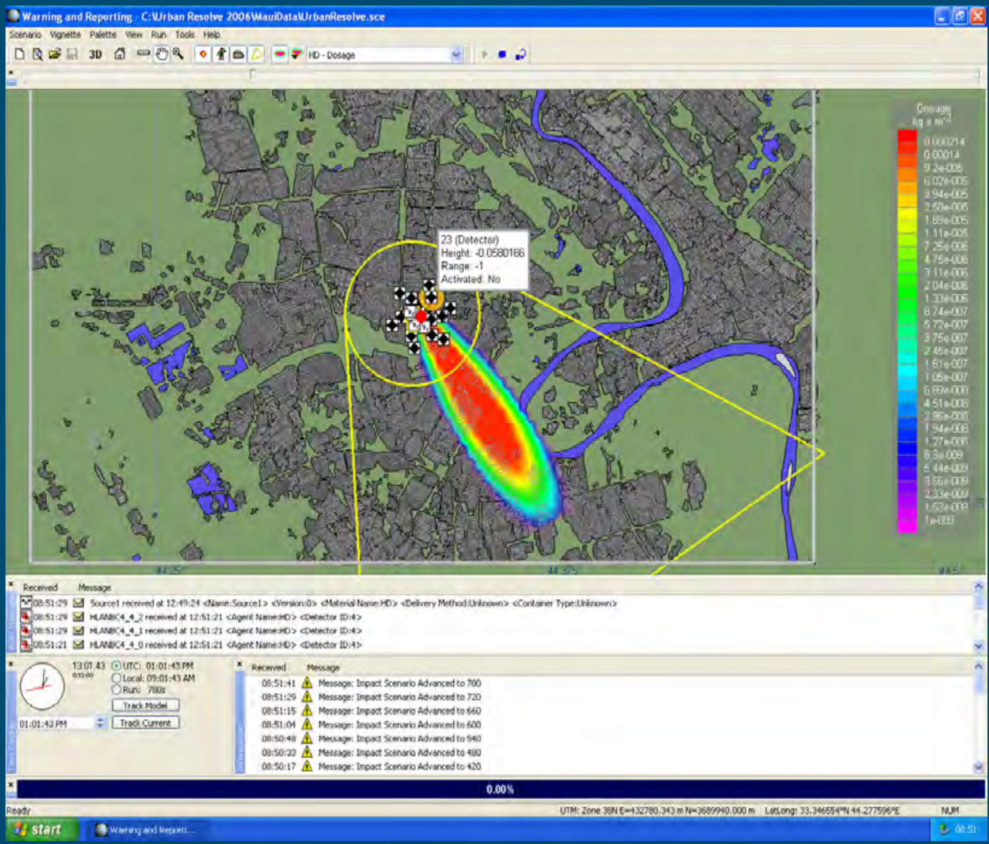


Hazard Prediction Concept Demonstrator

- The Concept Demonstrator consists of
  - SAFE Warning & Reporting, including STEM
  - Alternative Courses of Action Capability
  - REACT hand-held commander's tool
  - Sensor Placement Operational Tool (SPOT)

SAFE Warning & Reporting

- Warning and Reporting system includes
  - Source Term Estimation
  - ATP-45 style templates
  - Ensemble Average Hazard prediction



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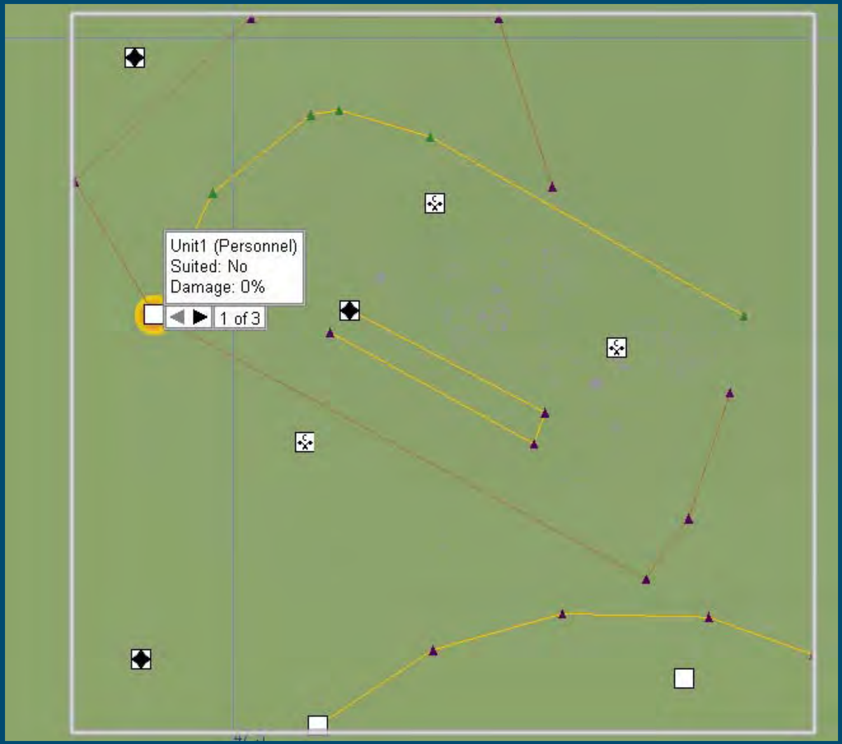
Alternative Courses of Action Capability

- ACAT tool allows alternative routes around plume to be evaluated.
- Hazard provided by the W&R Concept Demonstrator



REACT hand-held commander's tool

- Rapid Evaluation and Awareness Command Tool (REACT)
- Displays CBRN situational picture from W&R Concept Demonstrator on a PDA
- Allows observer messages to be send into W&R Concept Demonstrator
- Allows investigation into and evaluation of hand-held PDA devices for operational hazard prediction systems

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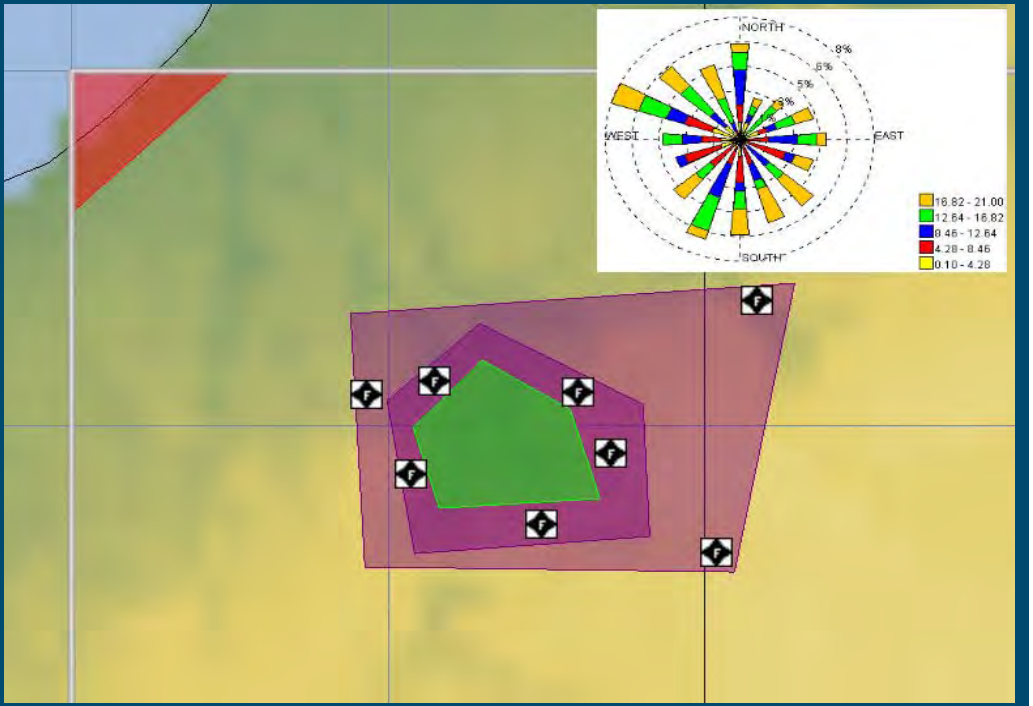
Sensor Placement Operational Tool (SPOT)

- Monte Carlo parameters
  - Wind speed / direction
  - Release type
  - Agent type
  - Time of release
  - Mass
- Use optimization techniques to place sensors
  - Genetic Algorithm
  - Simulated Annealing
  - Greedy Algorithm

Wind rose

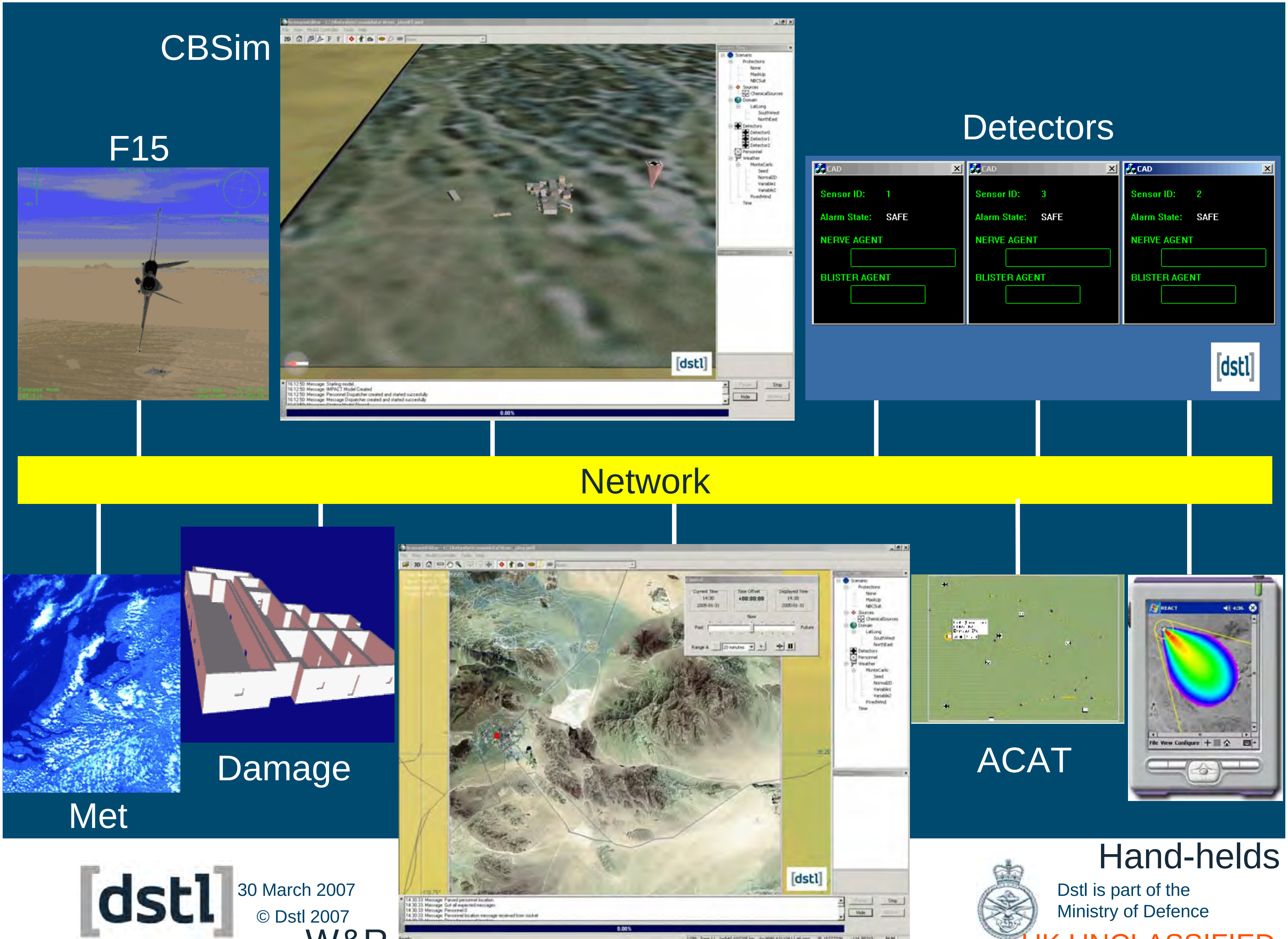


Optimal sensor placement to protect green area, including desirable (purple) and exclusion (red) areas

Application 1: Input into Collective Training

JFCOM J7 Joint Virtual Training Special Event 2005

- DTRA provided CBRN input into Collective training systems
- Systems involved
  - SPOT
  - CBSim
  - Detectors
  - Warning and Reporting Concept Demonstrator
  - ACAT tool
  - REACT PDA
  - External systems
    - OASES and WALTS



30 March 2007

W&R

Dstl is part of the
Ministry of Defence

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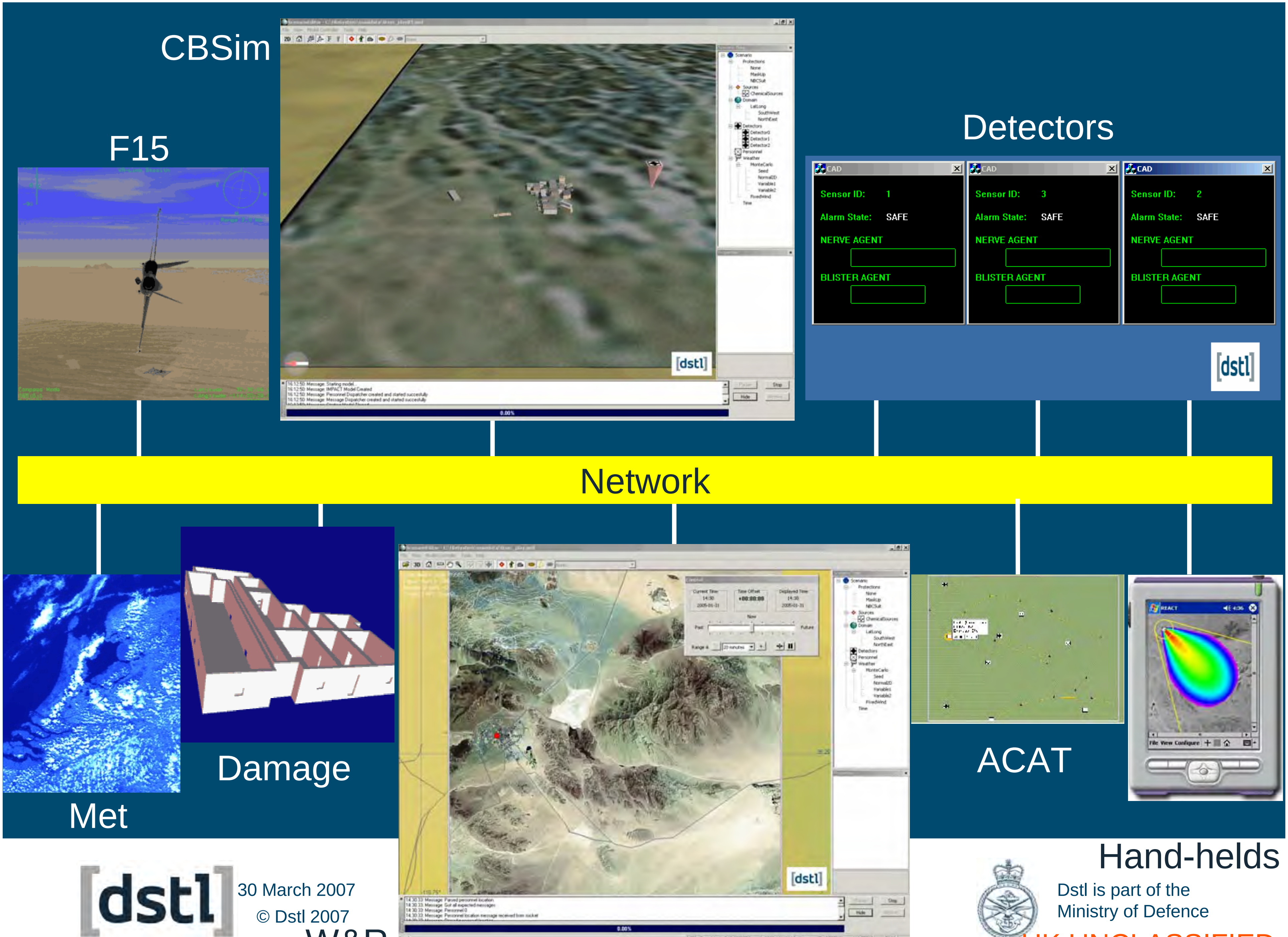

30 March 2007

W&R

Dstl is part of the Ministry of Defence

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Application 2: Experimentation

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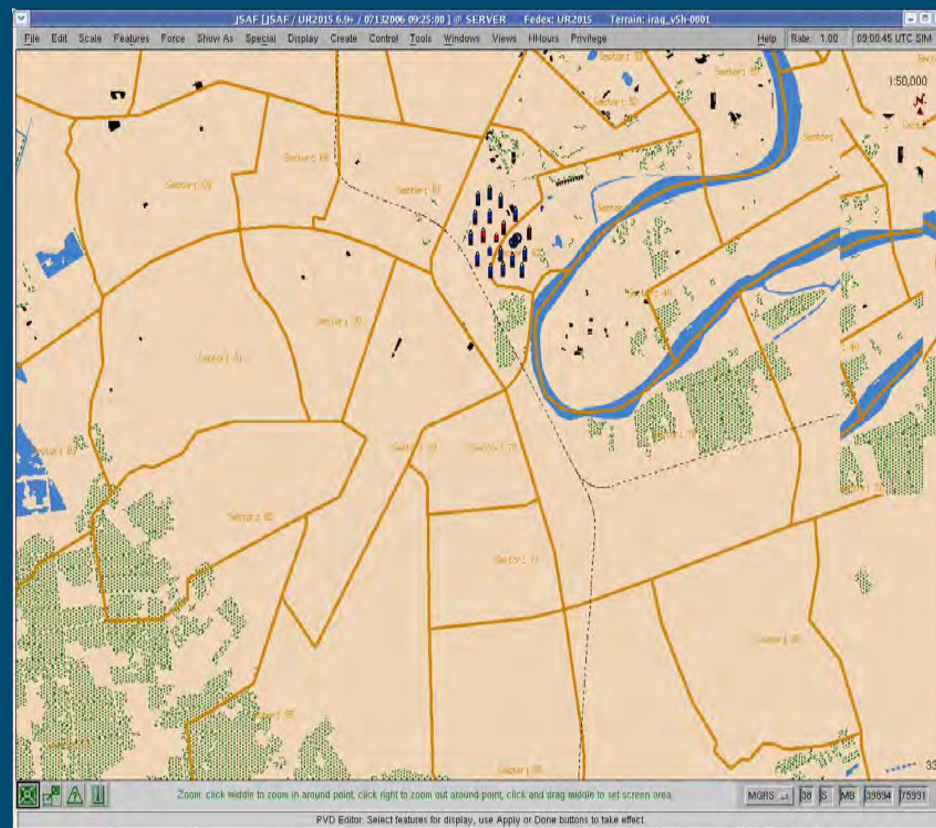
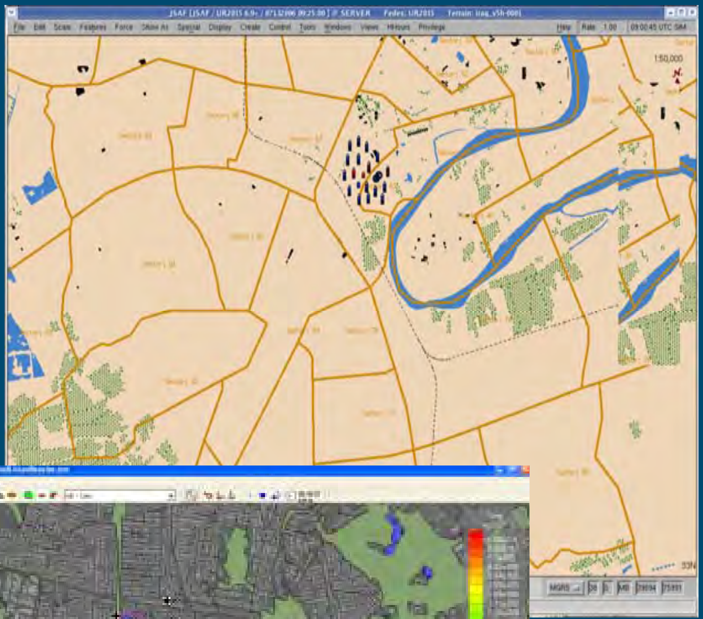
JFCOM J9 Urban Resolve 2015 Experiment

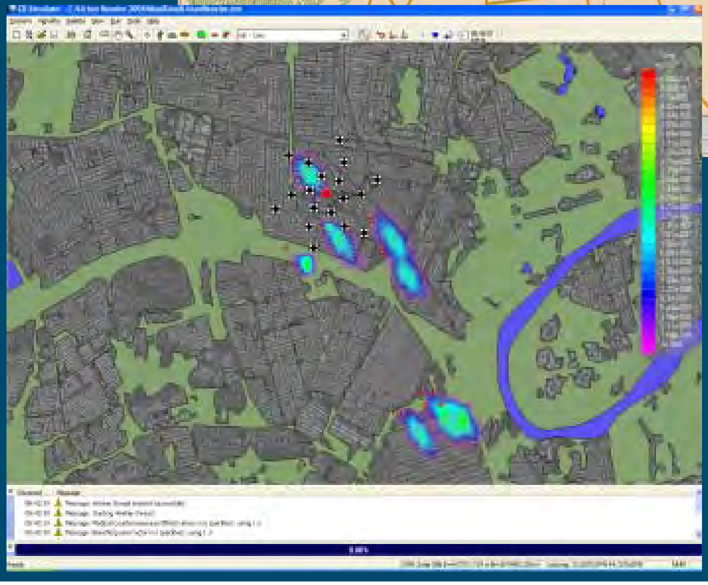
- Assess effect of technologies which will be available in 2015 against a 2005 baseline
  - Overall scenario is peace enforcement in Baghdad



JFCOM J9 Urban Resolve 2015 Experiment

- CBRN component
  - Assess effect of potential integrated CBRN defence solutions
  - Effort led by DTRA & J8 JRO CBRND
  - Ground truth provided by CBSim
  - 2005 capability represented by HPAC
  - 2015 capability of JWARN/JEM/JOEF
    - Emulated by SAFE W&R and associated tools

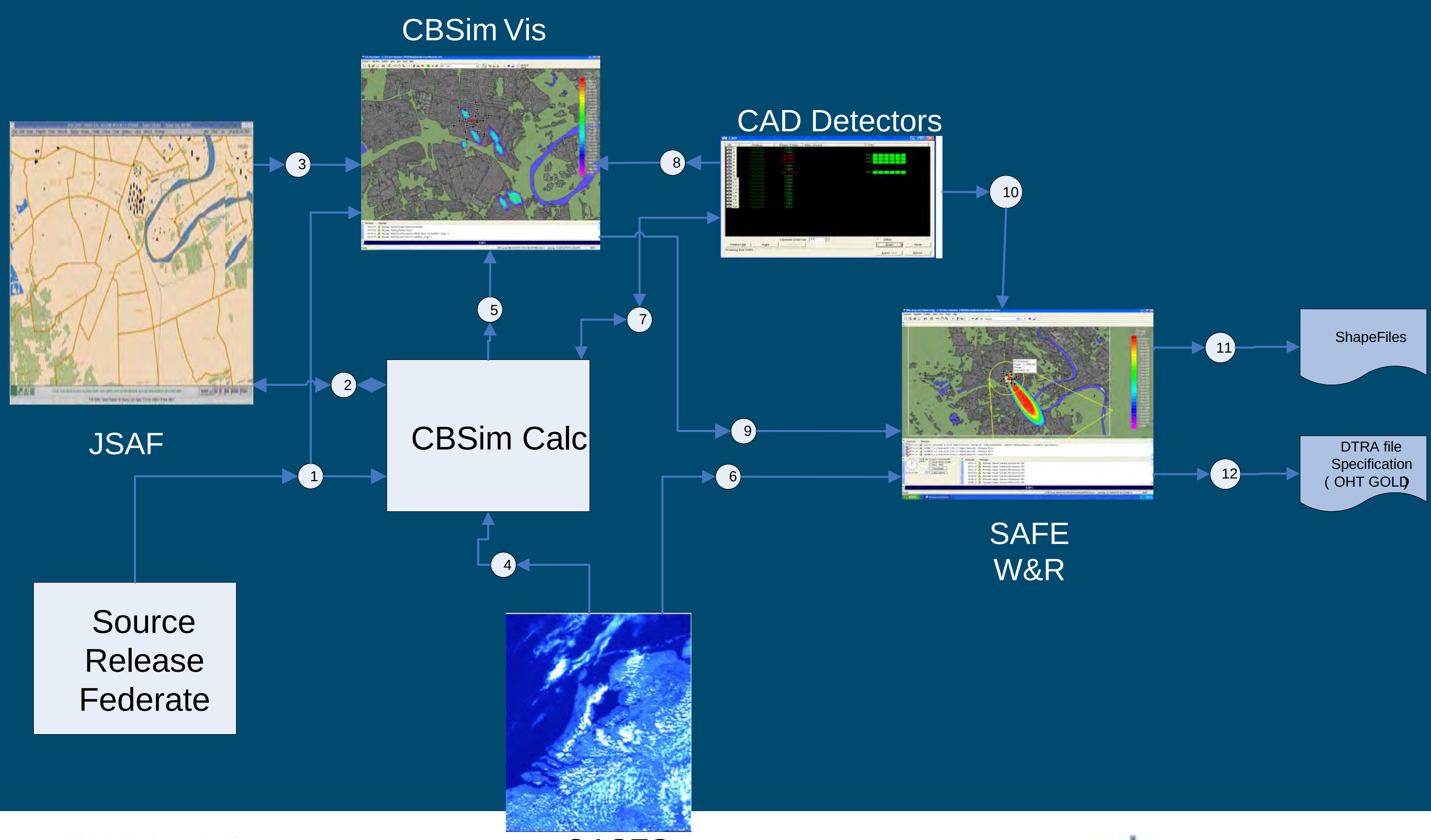




CBRN and Supporting Components

- Source release federate – modelled sources
- OASES – provided weather to federates
- CBSim – provided ground truth and CB effects on JSAF entities
- CAD Detectors
- JSAF – – modelled Iraqi military, some US military, and non-military entities (Iraqi police, insurgents, NGO, civilians, others)
- SAFE warning & reporting concept demonstrator
  - Includes source term estimation, ATP-45 & plume prediction
  - Emulated key required capabilities for JWARN/JEM

JFCOM J9 Urban Resolve 2015 Experiment



Details

- Releases
  - Munition detonation (120mm motar attack) mustard
  - 11,500 gallon chlorine tanker truck
    - Several levels of damage modelled dependent on attack
- JSAF modelled ~230,000 entities in Baghdad
- CBSim
  - Modelled dispersion for multiple sources
  - Provided updates of CB casualty states due to contamination to ~10,000 (peak 30,000) entities every 5-20 seconds
- SAFE W&R concept demonstrator
  - Fused detector readings to estimate source term
  - Modelled ensemble plume hazard
  - Exported hazard contours compatible for display on COP

Urban Resolve 2015 Results

- CBRN systems must be integrated with the entire battlespace awareness and command and control suite of the Joint Task Force
- CBRN events unfold over a significant amount of time – speedy response based on solid data and good analysis saves lives
- Future CBRN systems and processes require non-military functionality (e.g. political, economic and social)

Summary

- Presented DTRA led applications of CB simulation capability in
  - Training (JFCOM J7 JVTSE)
  - Experimentation (JFCOM J9 Urban Resolve)
- M&S capability demonstrably able to meet requirements
  - Significant enhancements made
- Experimentation results of benefit to decision makers, guiding future programmes

Future Plans

- Enhancements to CBSim
  - Performance improvements
  - Potential to increase functionality, e.g.
    - Improved meteorological modelling
    - Biological background
    - Advanced CB protection models
    - Improved human effects modelling
    - Physiological burden
- Exploring possibility of linking/integrating capabilities with IWMDT/IWMDTSim

Urban Dispersion and Data Handling in JEM

Ian Griffiths, David Brook & Paul Cullen (Dstl)

Tim Dudman & Russell Mills (RiskAware Ltd)

Rick Fry (DTRA)

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Acknowledgements

- Ian Sykes and Steve Parker – L-3 Titan
  - Support for link between SCIPUFF and UDM
- Tom Smith and Curt Wall – JPM-IS
  - Supply of JEM IRC MOUs
- DTRA
  - Supply of JEM through IRC MOUs

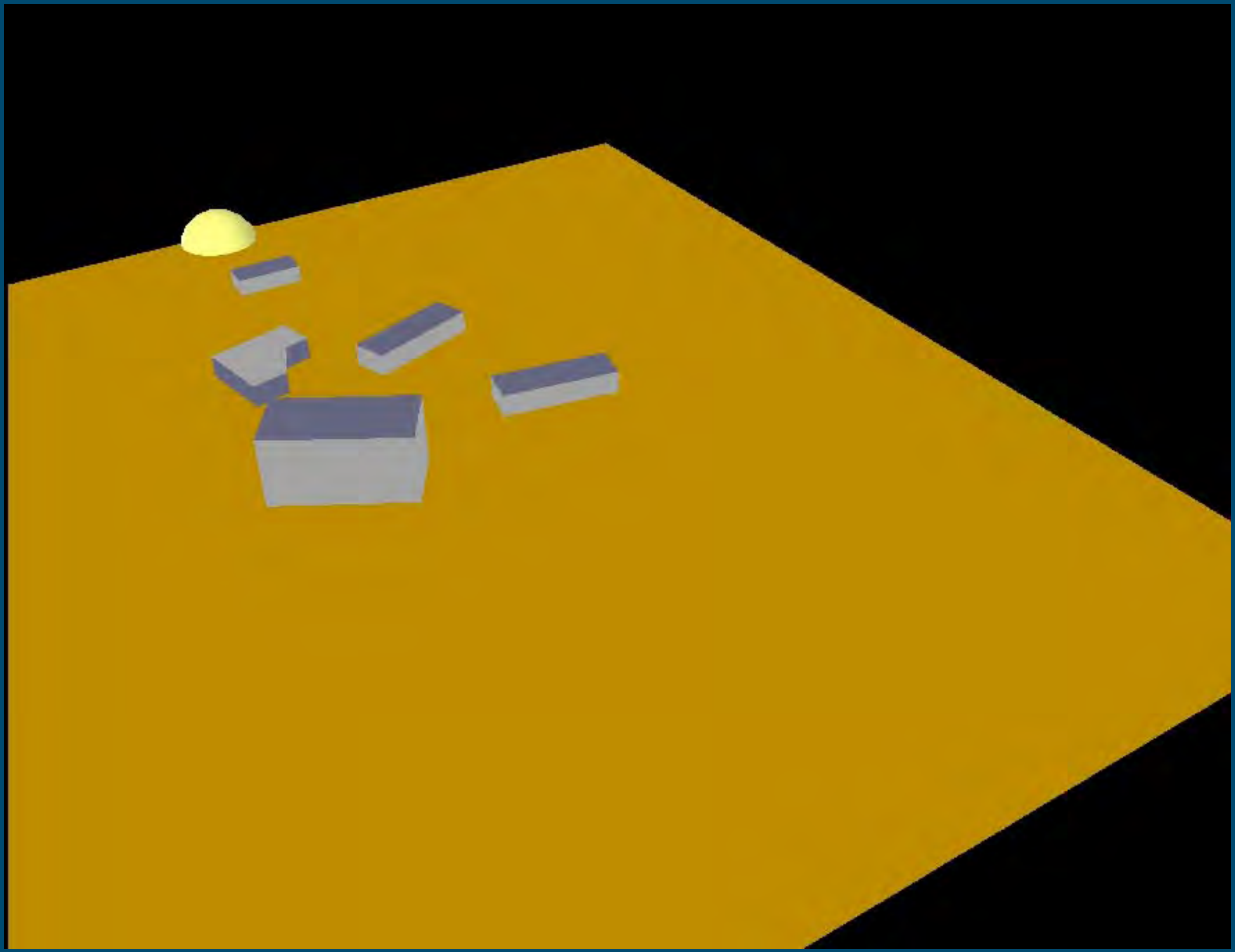
Overview

- UDM
- GEDIS
- JEM Urban Modelling Prototype (JUMP) development
- JUMP demonstration
- Future plans

Dstl's Urban Dispersion Model (UDM)

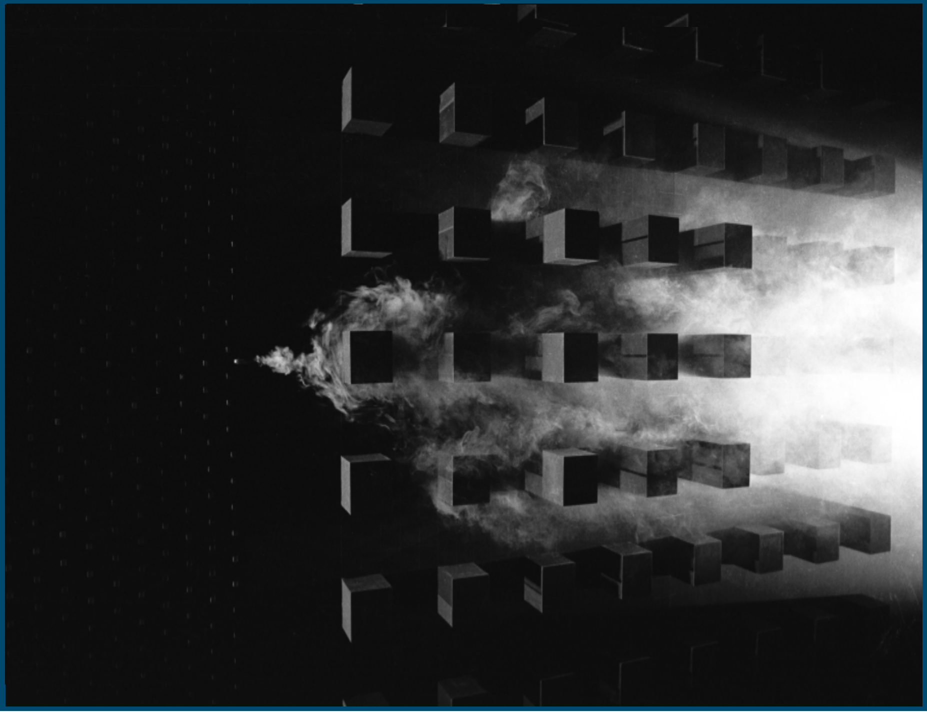
UDM - Open Regime

- Gaussian puff model
- Open regime - puffs interact with individual, isolated buildings

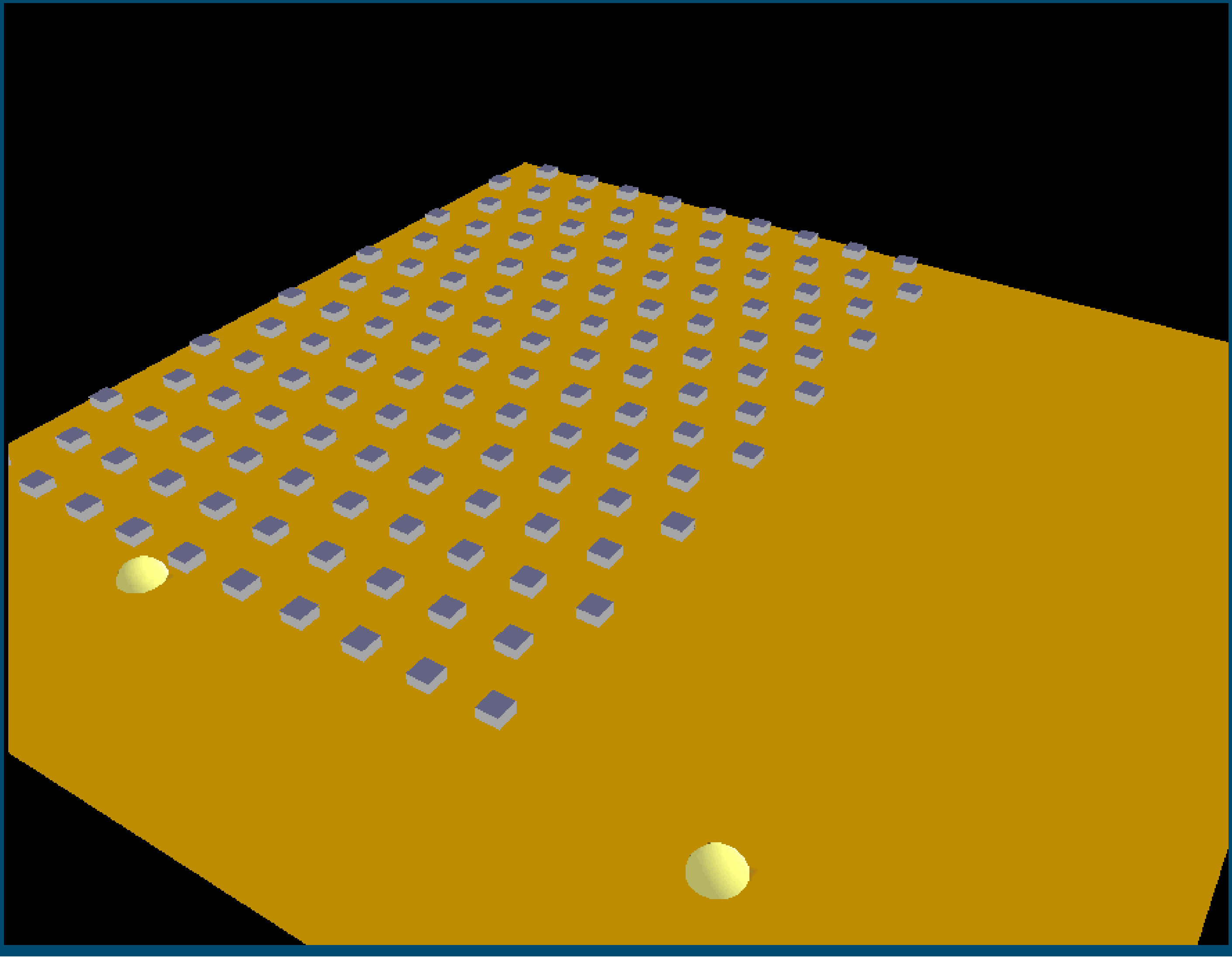


UDM - Urban Regime

- Urban regime - puffs interact with array of buildings, dependent on
  - Puff height, building density, mean building height and width, wind direction, array being square or staggered
  - Data from 2500 wind tunnel experiments



UDM - Urban Regime



UDM - Key Features

- Link to GEDIS building database
  - Urban morphology extractor
  - Efficient
  - Robust to different representations of complex buildings
- Includes liquid droplets and particulates: size-dependent wet and dry deposition
- Includes secondary evaporation
- Various sources - moving, static, point, line, area, etc

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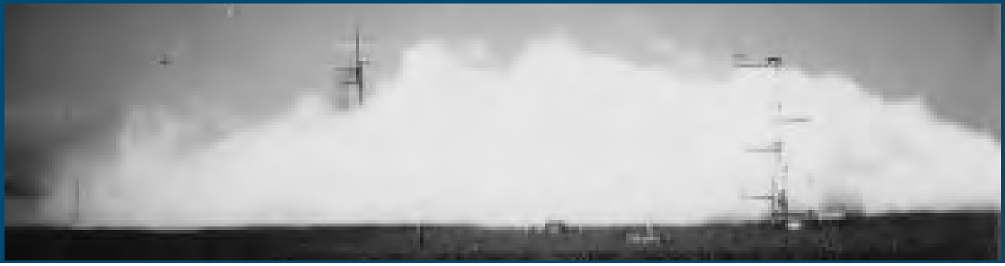
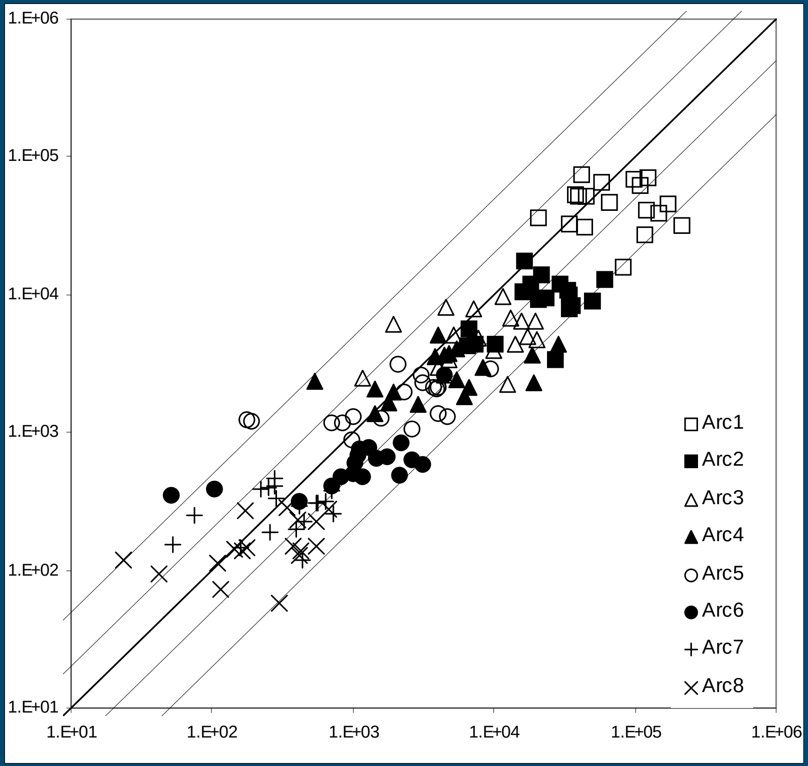
Recent Developments

- Replaced R91 (stability category) by AERMOD (Monin Obukhov length based)
- Courtyard model added
- Radiological cloud shine
- Puff rise model
- Dense gases

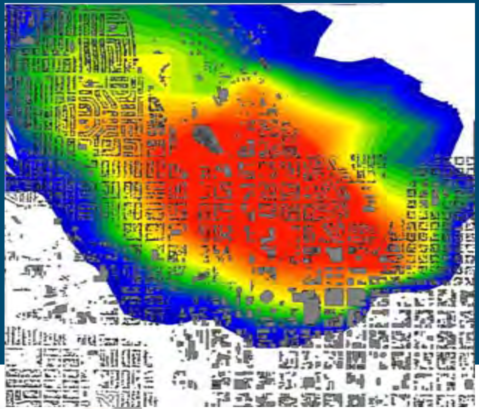


Validation Status

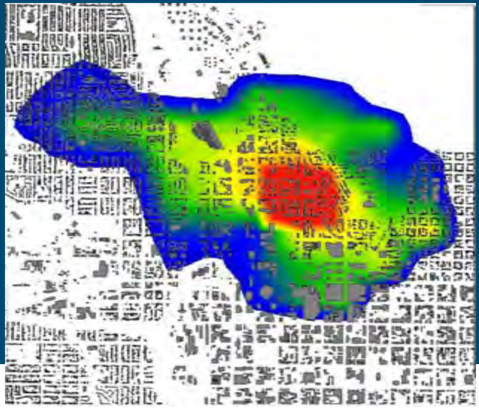
- Predictions from several urban models independently evaluated against data from URBAN 2000 (Salt Lake City), MUST (DPG) & JU2003 (Oklahoma City)
  - UDM performs well
  - Further validation being performed



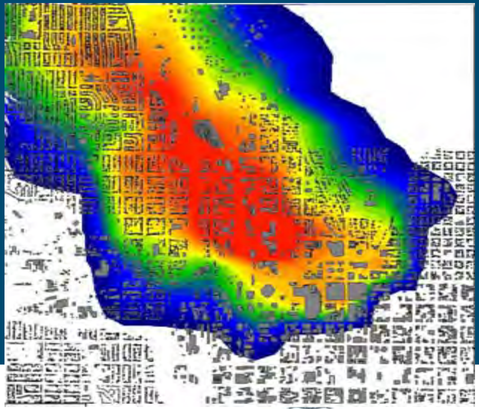
Observations



Non Urban Model

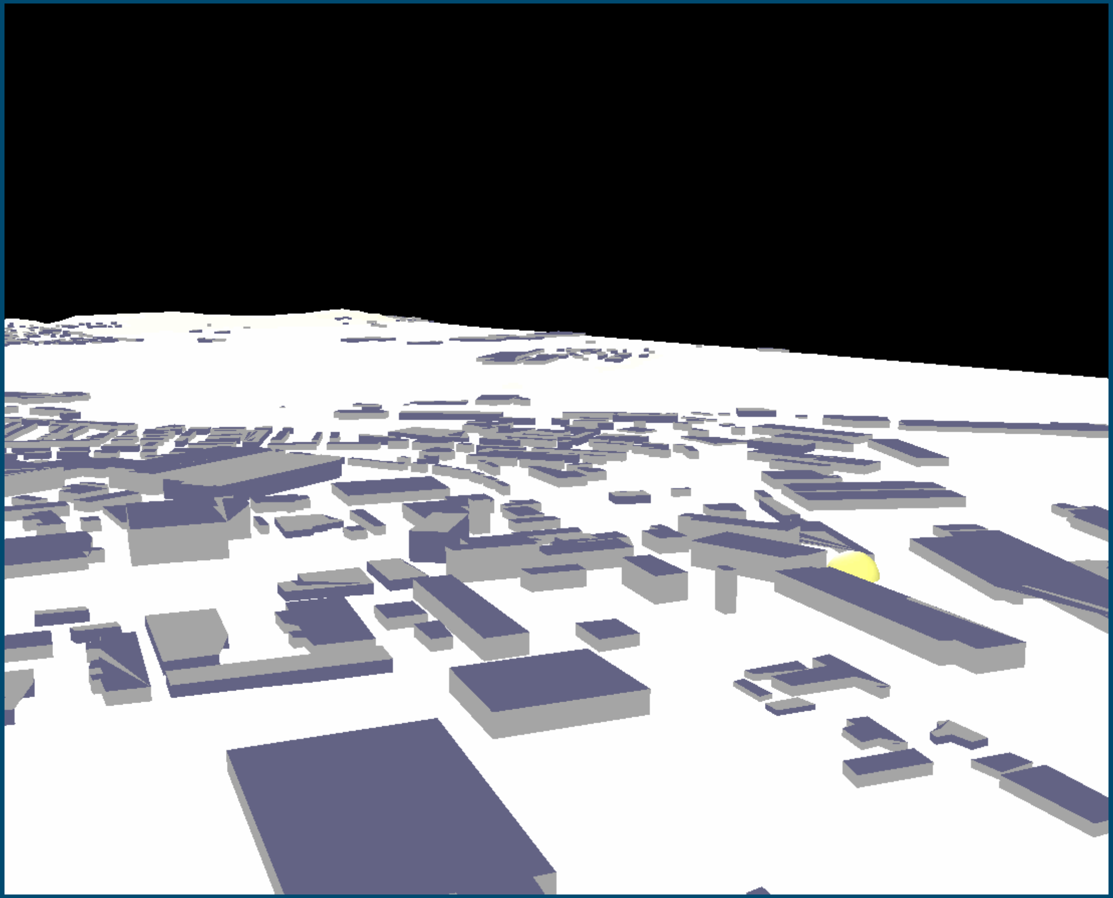


UDM



SCIPUFF-UDM Link

- SCIPUFF able to provide all source puffs to UDM
- UDM models dispersion of each individual puff while interacting with buildings and urban ground areas
- UDM returns individual puffs to SCIPUFF when roughness canopy modelling appropriate
- Results of both models combined in SCIPUFF



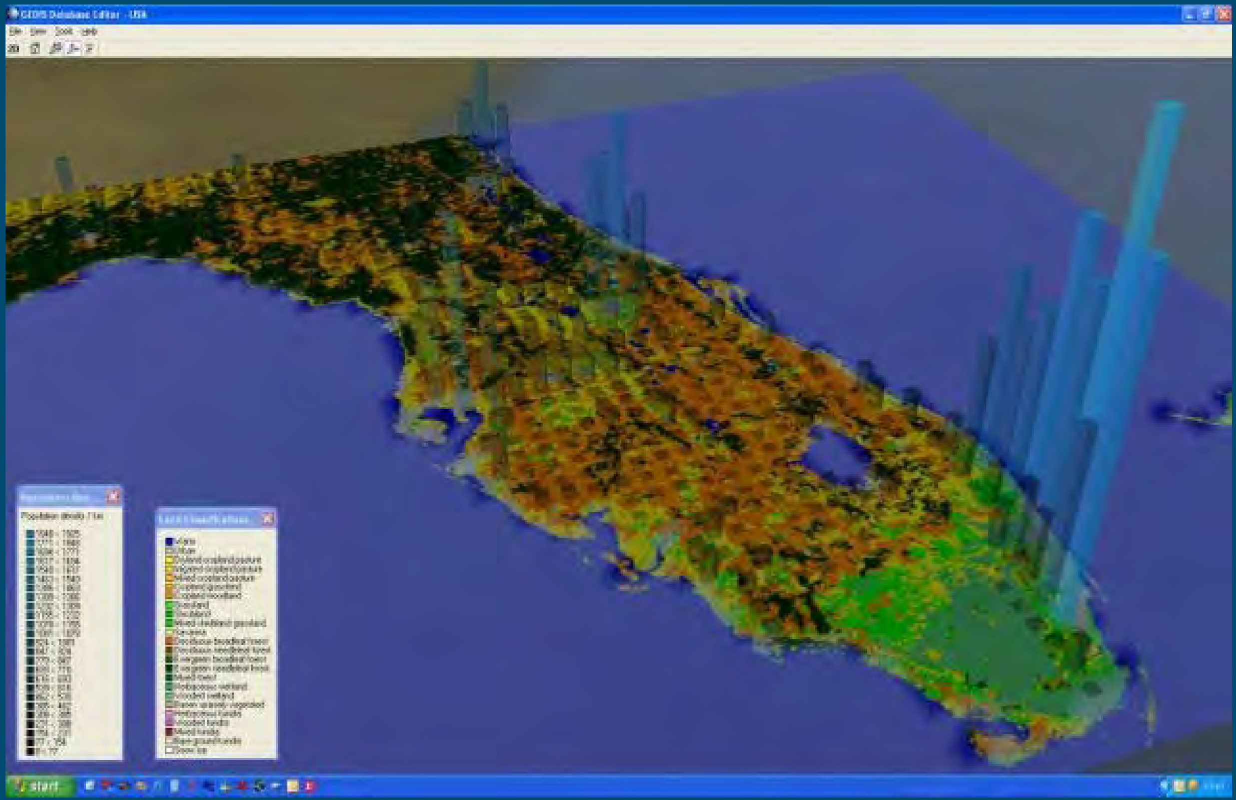
The Geographic Environmental Database Information System (GEDIS)

GEDIS Overview

- Developed by Dstl for UK MOD and US DTRA
  - Subject of TTA for use in JEM
- Comprises set of GIS components & associated toolset applications
- Originally developed for storing urban data for urban dispersion models
  - Include data pre-processing, cleanup & quality assurance
  - Rapid data access
  - Import & export in standard formats (e.g. shapefile)
  - Rugged, with high level of testing
- Used by several urban models
  - UDM, UWM, MSS

GEDIS Elements (1)

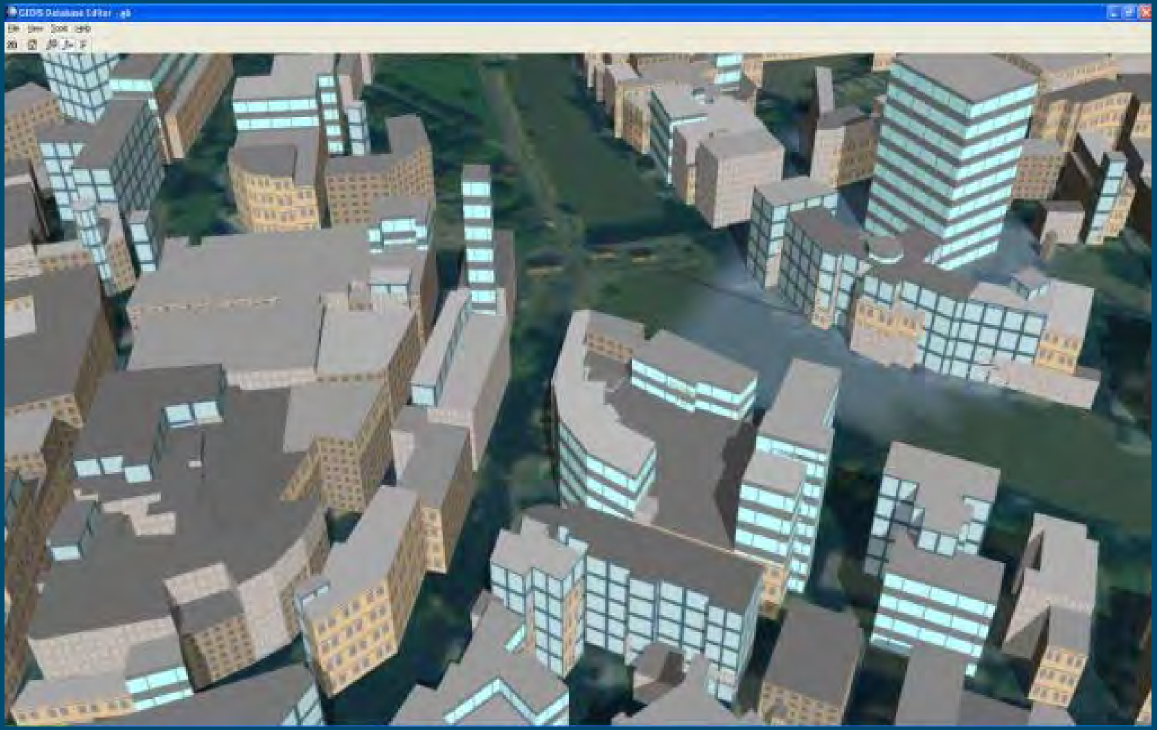
- Gridded data manager, stores
  - Multiple-resolution DTED terrain
  - ORNL population density data
  - USGS land classification data
  - Georeferenced aerial imagery



Land classification and population density data for Florida

GEDIS Elements (2)

- Spatial object manager, stores
  - 2½D buildings with composite parts and courtyards
  - urban ground regions (for UDM)
  - Linear features such as roads and rivers
- Spatial R-tree architecture used to provide efficient access to feature data
- Queries based on coordinates & domains, with filters



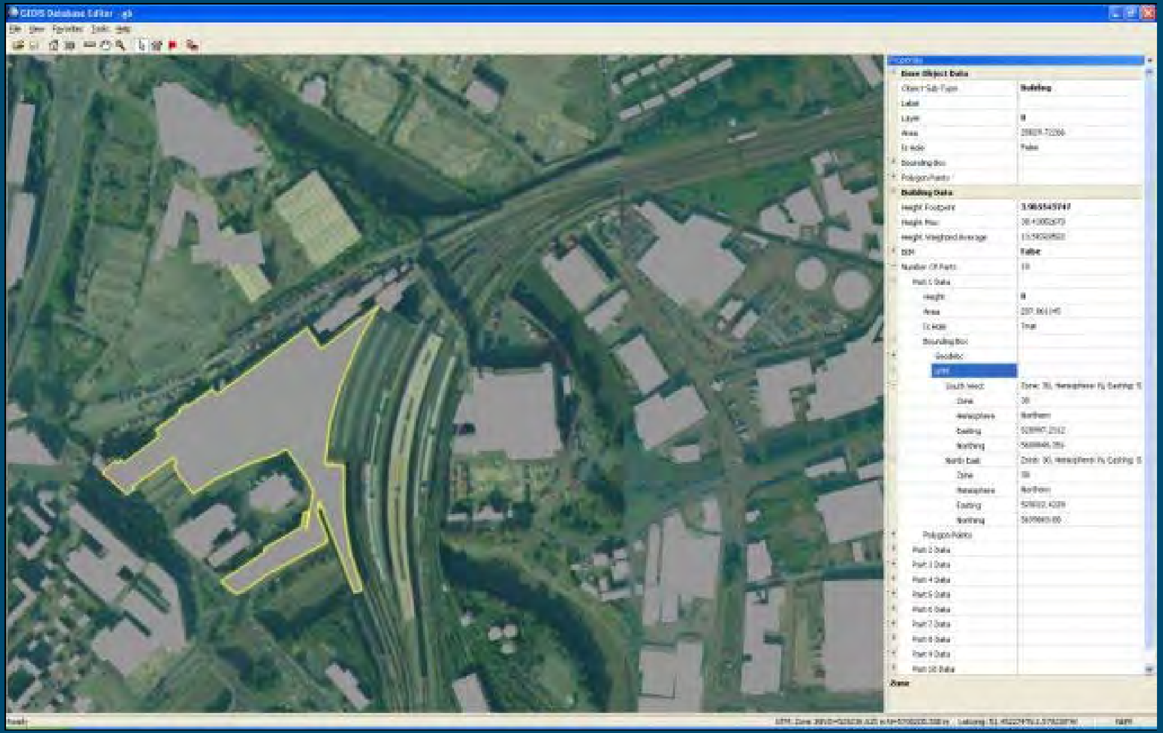
2½D composite buildings stored in GEDIS

GEDIS Elements (3)

- Fusion of terrain, aerial imagery and building data

GEDIS Toolset Applications (1)

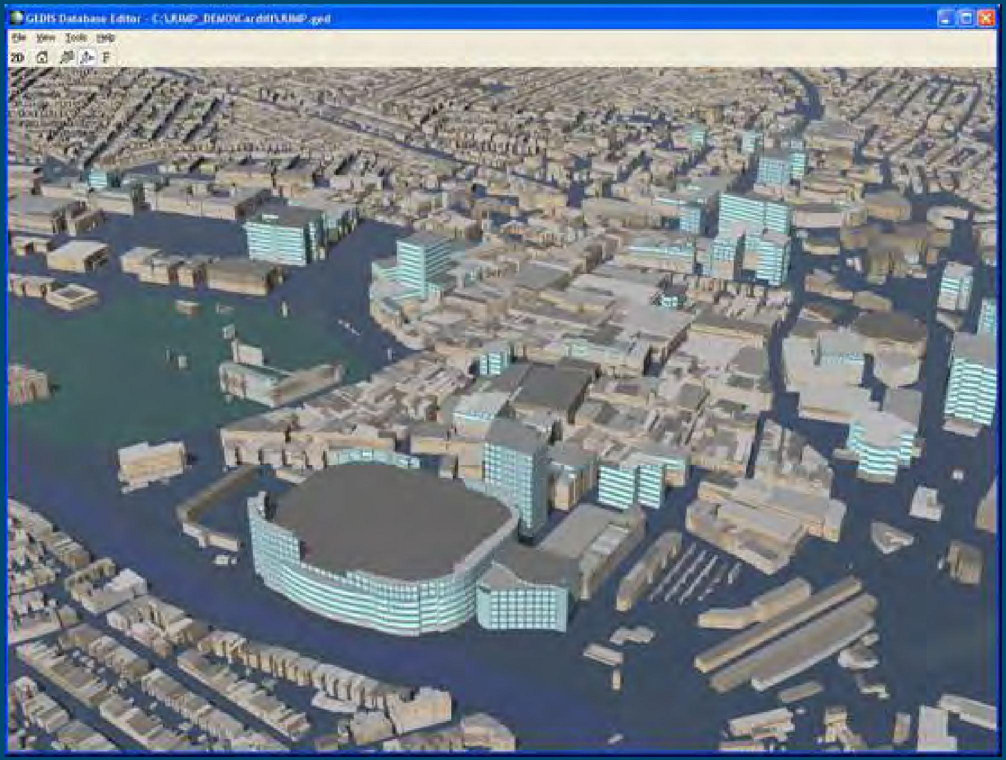
- GEDIS Database Editor (1)
  - Allows visualization, creation, export and feature editing capabilities as a desktop application



Feature editing in the Database Editor

GEDIS Toolset Applications (1)

- GEDIS Database Editor (2)
  - Allows visualization, creation, export and feature editing capabilities as a desktop application



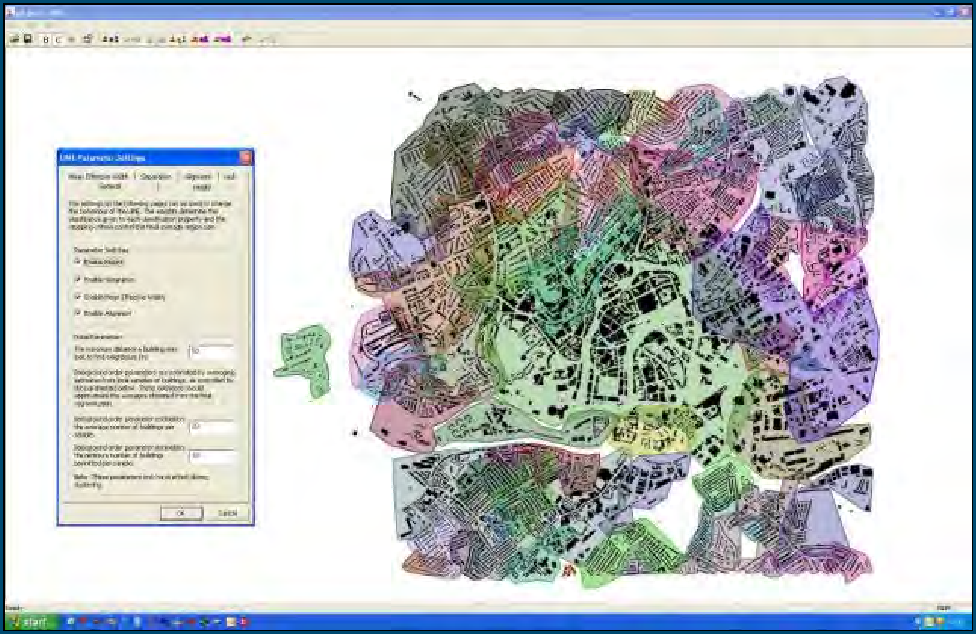
3-D Visualization in the Database Editor

GEDIS Toolset Applications (2)

- Urban Density Calculator
  - Specifically designed to integrate GEDIS object representation of features with UWM (and similar models)
  - Feature data rasterized and urban properties such as canopy height & urban density calculated
    - Returned as UTM raster grids

GEDIS Toolset Applications (3)

- Urban Morphology Extractor (UME)
  - Semi-automatically pre-processes building data to form homogenous areas categorised by various urban parameters (height, street alignment, building size and separation)
  - Areas created using statistical clustering algorithms
  - Data saved along with building data as urban ground areas
  - Provides client applications bulk properties of urban environments
    - These urban areas crucial to UDM calculations



UME User Interface

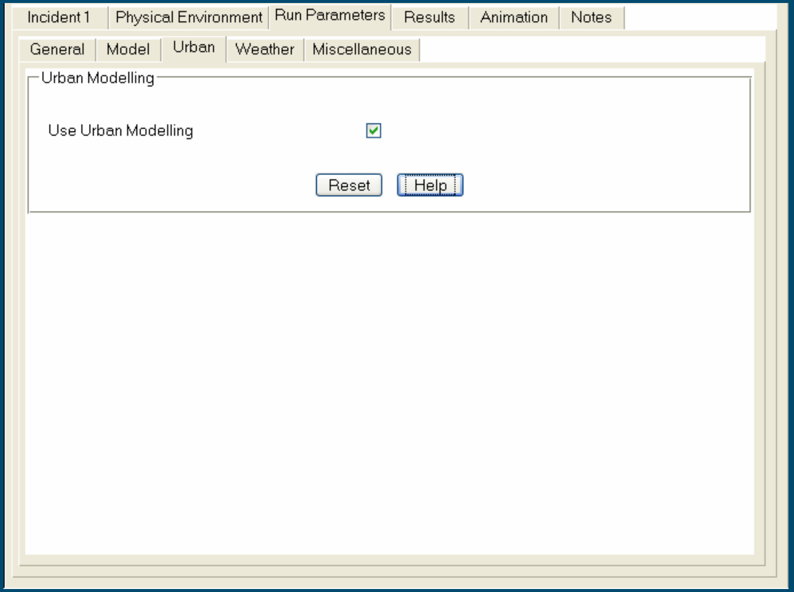
Handling New Datasets

- Import source data
  - Import data as
    - Point, line, polygon, polygon-z data in ESRI Shapefile format
    - Raster data in any number of formats including DTED, Jpeg, and Bitmap
  - Tools includes conflation capabilities, allowing two separate datasets or sub-datasets to be merged into a single dataset
  - Duplicated or overlapping data can be automatically removed or merged
- Run UME on data
- Replace or augment current database

JEM Urban Model Prototype (JUMP)

- Being developed to de-risk urban capability in JEM increment 2
  - Provides capability to demonstrate & also consider urban data issues
- JPM-IS / JSTO selected UDM for prototype as
  - Typical of urban models in terms of data requirements
  - Highly modular & easy to integrate
  - Proven capability

JUMP Development Tasks

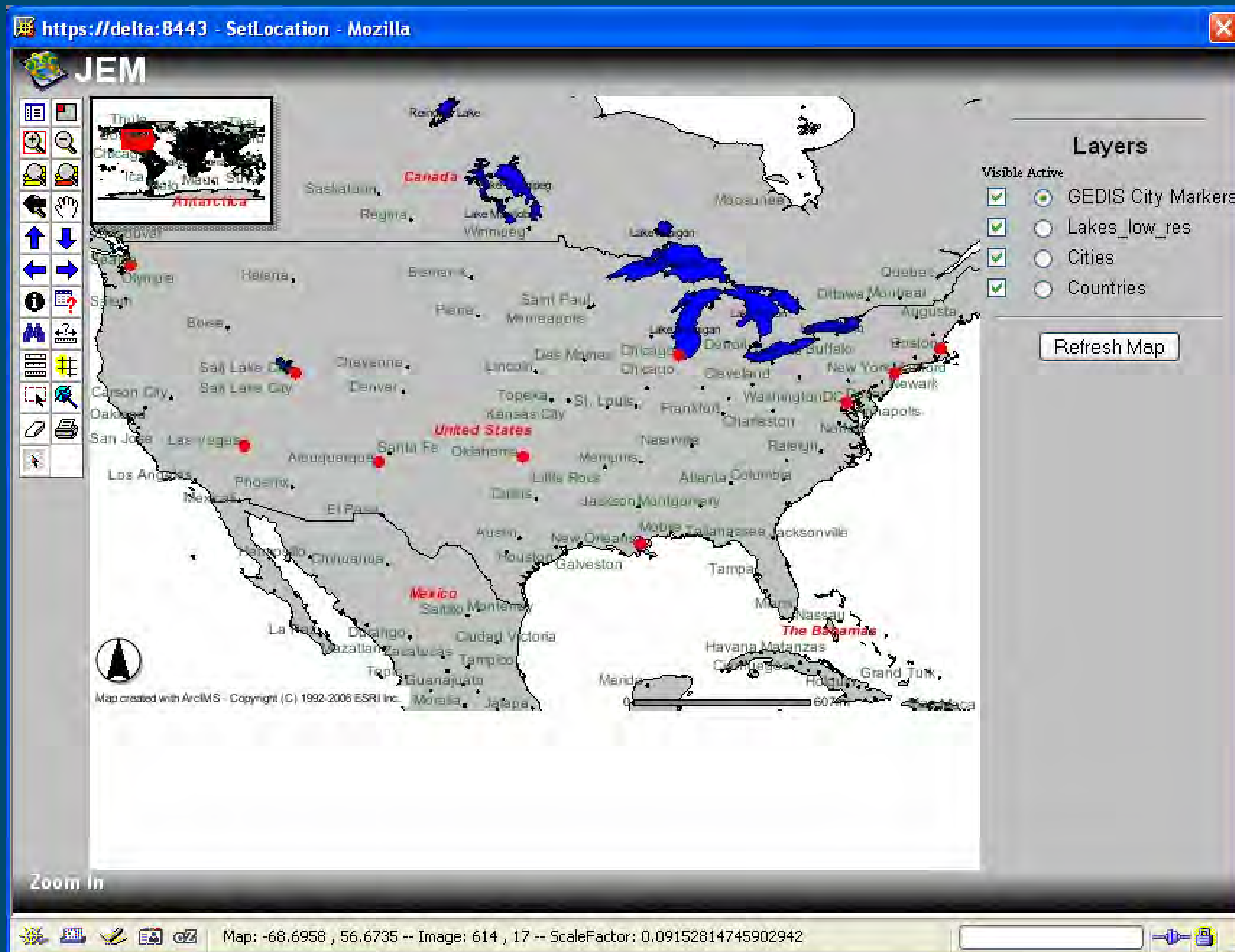


- Phase I
  - Activate UDM calculation in JEM
  - Display UDM output in JEM GUI
    - No buildings shown
- Phase II
  - Update to latest UDM & GEDIS
  - Include urban model controls in JEM GUI
  - Display urban data on the JEM ARCIMS map screen
    - Displayed urban data fixed & cannot be updated by user (data used in dispersion calculation can be)

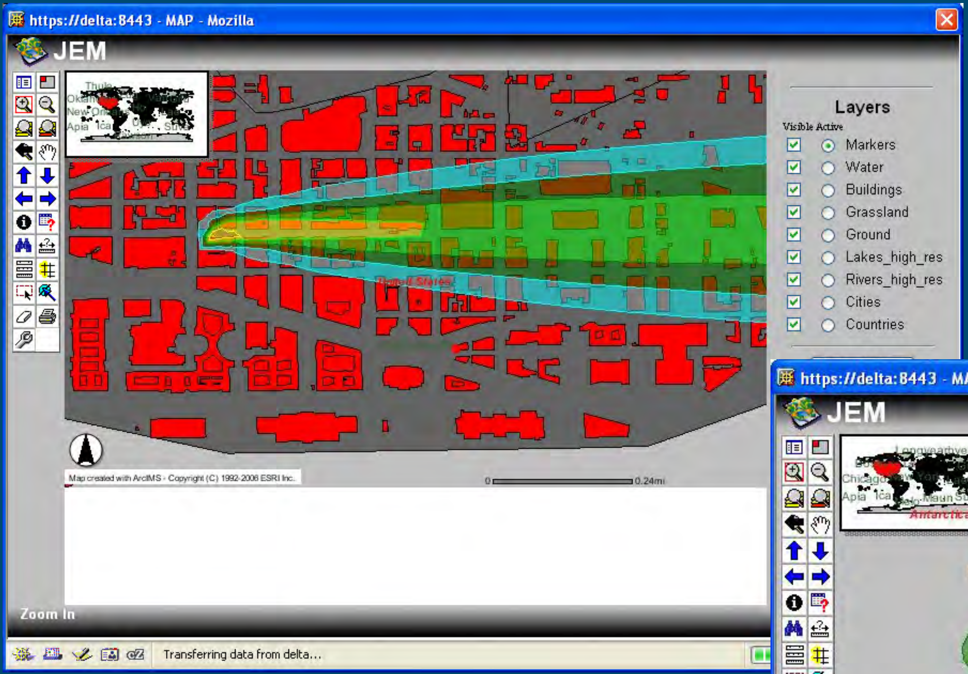
JUMP Development Tasks

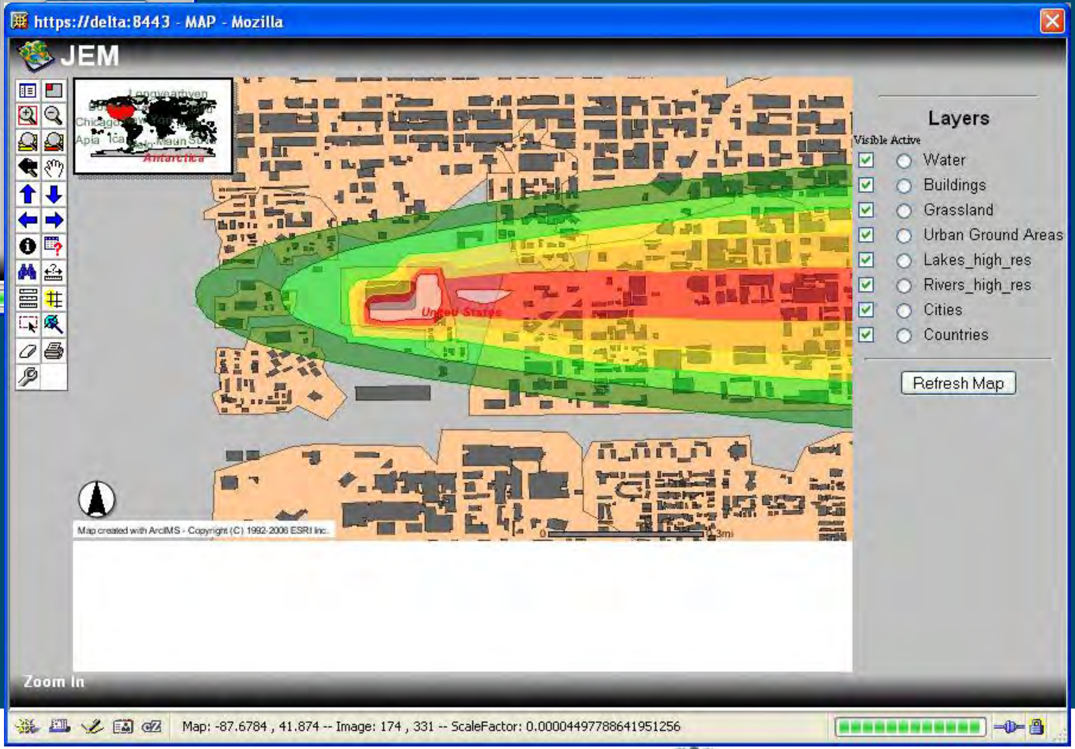
- Phase III
  - Export of geographic layer by GEDIS
  - Modelling service updates for geographic layer transfer
  - Visualisation service updates for geographic layer transfer
    - When urban database updated, ArcIMS background map layers are automatically synchronized
    - JEM administrator can then update urban data displayed
    - Requires JEM restart as JEM update capability not yet active
  - Create installation patch

JUMP Example Screenshots (1)



JUMP Example Screenshots (2)





JEM Urban Modelling Prototype Demonstration

Future Plans

- Complete testing & documentation
- Patch installation delivered to JSTO Jan 2007
  - Will not be included in general JEM release
- UDM & GEDIS both subject of TTAs for JEM

Threat Agent Science Capability Area CBIS 2007

Frank Handler, Ph.D.
Threat Agent Science CAPO

January 9, 2007

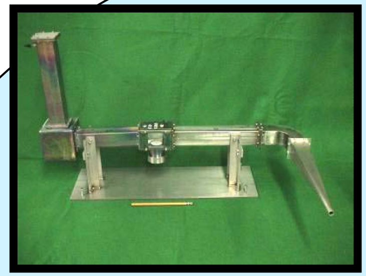
Agent Fate enhances predictive tools with data, quantifying the fate of chemical agents within operationally significant climates and surfaces.

International Partners: CZ, POL, NLD, UK, and SGP

Wind Tunnel Testing

Measures evaporation of agent from surface at realistic climactic conditions. Main data input stream for predictive models

Uses combinations of vapor sampling & gravimetric analysis



Outdoor Testing

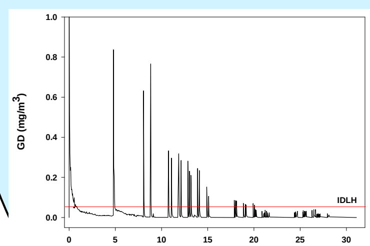
Validates model developed with wind tunnels data

Provides "ground truth" of behavior in environment

Agent/Substrate Interactions

Agent/Substrate interactions are critical component to determinations of fate.

Studies use highest fidelity methods including NMR, SPME, vapor resurgence, extractions quantitative imaging and fundamental property measurements



FM 3-4	
Liquid	**Vapor**
Not Avail	7 - 20+
Not Avail	20+
Not Avail	18 - 20+

FM 3-9	
Liquid	**Vapor**
Not Avail	5 - 48
Not Avail	6 - 168
Not Avail	800 -3600

VX

Modeling

Improves hazard prediction tool accuracy

Transitions information to warfighter in a usable format.

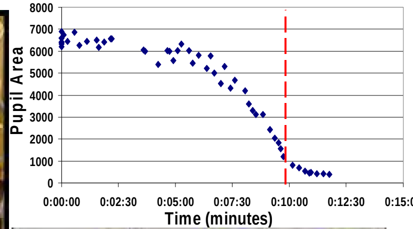
AGENTFATE

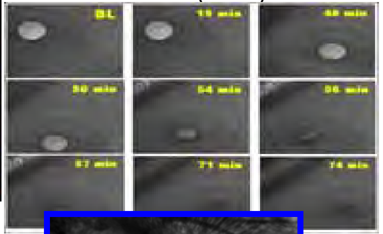
Physiological Effects
CWA Operational Exposure Hazard Assessment Research

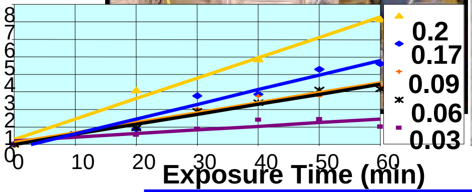
Purpose and Goal: Operationally-relevant health effects of exposure to the class of chemical warfare agents (CWAs) to include those termed "Non-Traditional Agents (NTAs)".

Exposure Studies
- Inhalation dose-response
- Percutaneous contact

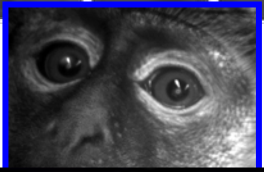
Integration Studies
- Route Extrapolation
- Human effects
- Mission/Hazard Profiling





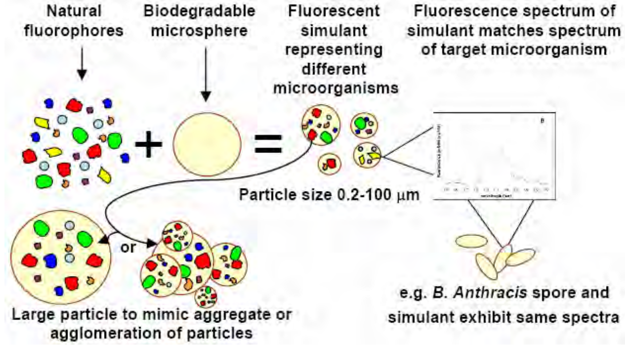


Health Effects
- Sub-Clinical effect
- Delayed/Persistant Toxicity
- Repeated exposures



PAYOFFS
- Operational Requirements and Standards
  - JPID
  - FM 3-11.9
  - AFMAN 1026-02
- Operability Modeling
  - JEM/JOEF
  - Agent Fate Link
- Reachback Expertise

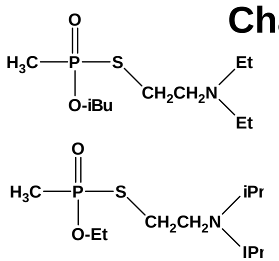
Agent Characterization/ Simulant Development



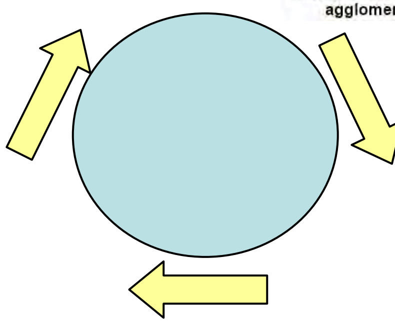
ECBC

R33

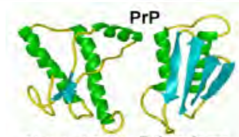
VX

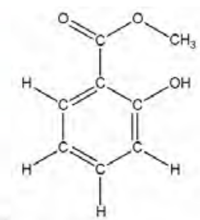


Agent Characterization



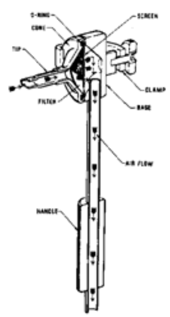
Simulant Development



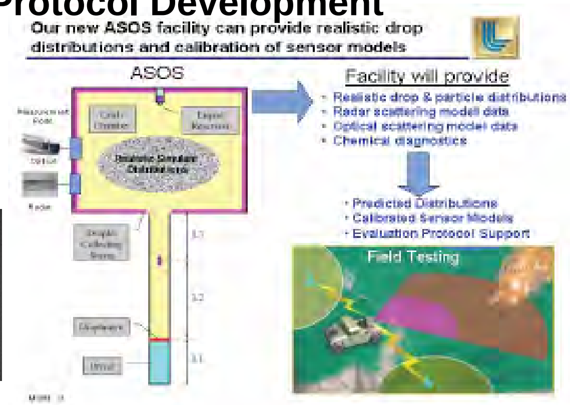


Methyl Salicylate

Avipox virion

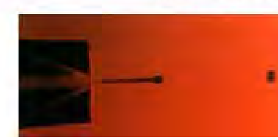


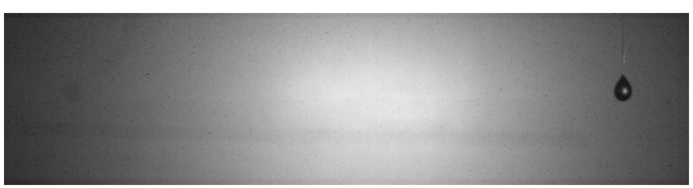
T&E Protocol Development



COTS 512-ELEMENT INKJET ARRAY MODULE

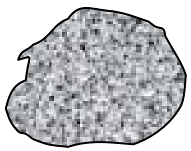
MODULE BANK





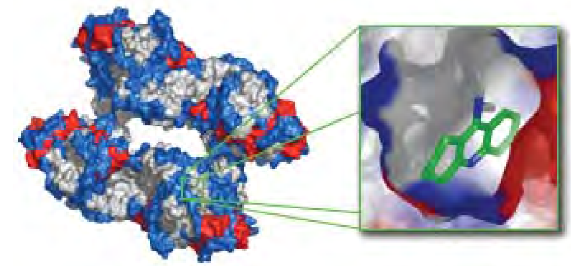
3.8%PSBMA/TBP, We=10199, d=3.7mm, 29470fps

Computational Chemistry provides fundamental understanding

CWA +  solid adsorbent +  quantum-chemical modeling

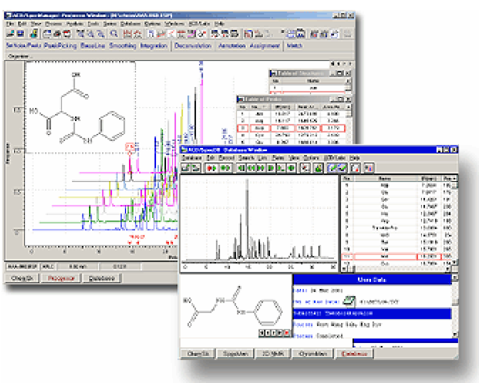
=
- *interaction parameters*
- *chemical properties*
- *environmental stability*

Intelligent Design of Materials & Simulants

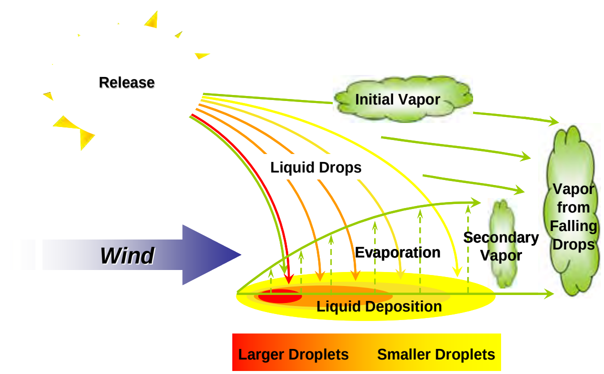


Tetramer of human acetylcholinesterase

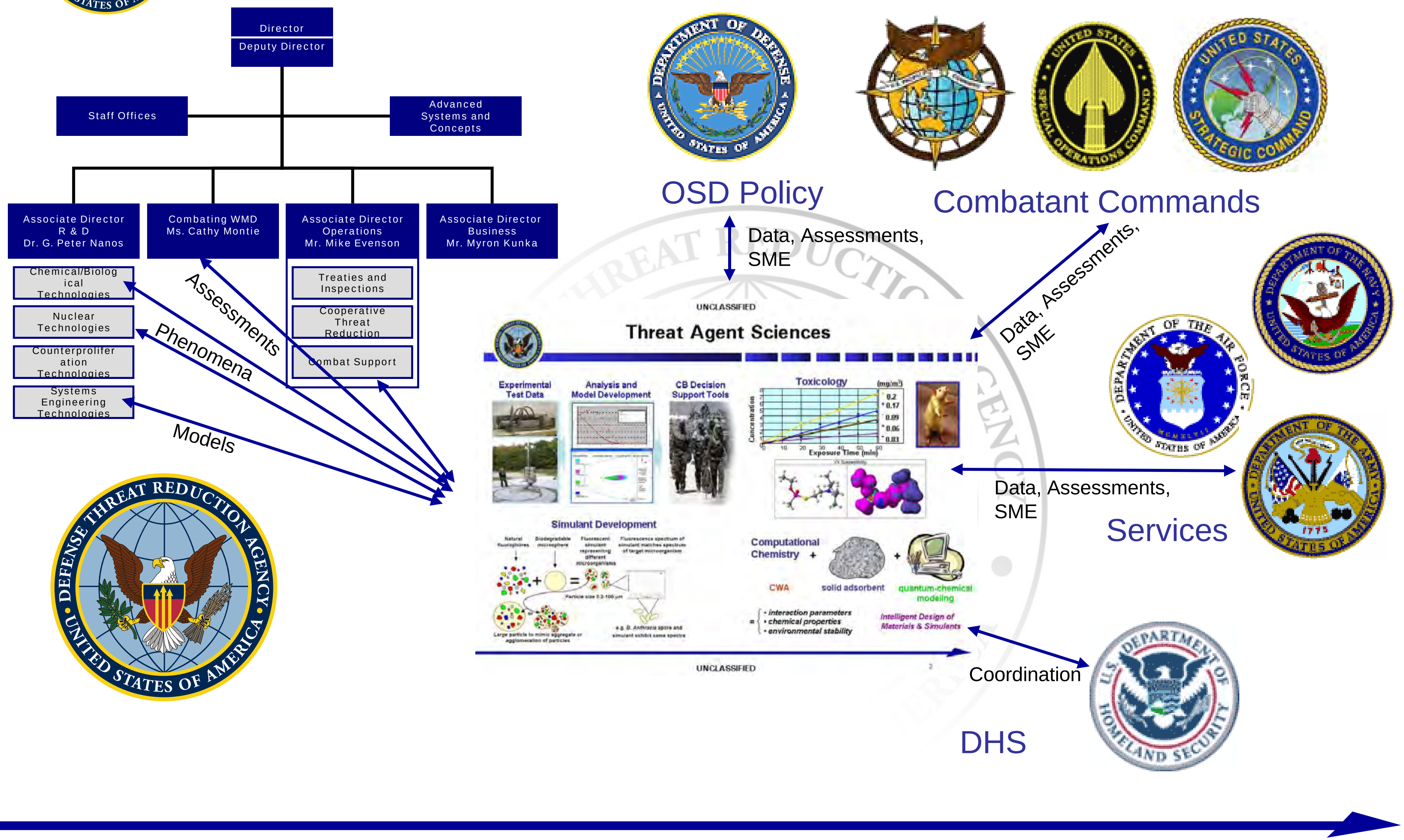
Tacrine bound in one active site of acetylcholinesterase



In-silico simulant selection
For CWA T&E



We provide data, models, and reachback expertise coordinated across the community



Estimating Emissions of Toxic Industrial Chemicals (TICs) Released as a Result of Accidents or Sabotage

Steven R. Hanna (Hanna Consultants), Gene Lee (Baker Engineering and Risk Consultants, Inc.), David Belonger (Center for Chemical Process Safety for the American Institute of Chemical Engineers), Peter J. Drivas (Drivas Consultants), Rex Britter (University of Cambridge), and Olav Hansen (GexCon A.S., Bergen, Norway)

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January 10, 2007

Presented at
CBIS Conference, Austin, TX

Outline

- Matrix of Highest-Priority Toxic Industrial Chemicals (TICs) and Source Scenarios
- Example of Chlorine Railcar Scenario and Emergency Response Guidelines
- Review of Source Emission Formulas and Models in Use and Recommendation of Specific Formulas
- Review of Field Experiments and Identification of Data Gaps where New Experiments are Needed

Matrix of Toxic Industrial Chemicals (TICs) and Source Scenarios

The goal is to determine the most dangerous Toxic Industrial Chemicals (TICs) and source scenarios, with focus on transportation scenarios

This task was mainly carried out by the CCPS/AIChE team, led by Dave Belonger

The main product is a table with rankings of the “top 13” TICs

CAS	Chemical		ERPG 3 ppm	Relative Volume Chlorine = 100	Vapor Pressure mmHg	Toxicity Factor (4)	Hazard Index (7)
			By Rail on CSX Line				
7782-50-5	Chlorine	Bulk	20	100	5168	3.40	340.0
7446-09-5	Sulfur dioxide	Bulk	15	5	2475	2.17	10.9
7664-41-7	Ammonia (anhydrous)	Bulk	750	25	6660	0.12	2.9
			By Truck				
7782-50-5	Chlorine	Cylinders (2)	20	100	5168	3.40	340.0
7664-41-7	Ammonia (anhydrous)	Cylinders (2)	750	800	6660	0.12	93.5
7446-09-5	Sulfur dioxide	Cylinders (2)	15	10	2475	2.17	21.7
7647-01-0	Hydrogen chloride anhydrous	Bulk	150	3	31700	2.78	7.8
75-44-5	Phosgene	Cylinders	1	0.3	1215	15.99	4.8
7726-95-6	Bromine	Bulk	5	8	175	0.46	3.9
107-02-8	Acrolein (6)	Bulk (1)	3	2	210	0.92	1.8
74-90-8	Hydrogen cyanide	Cylinders(2)	25	5	630	0.33	1.5
7790-91-2	Chlorine trifluoride (5), (6)	Cylinders	10	2	346	0.46	0.9
79-22-1	Methyl chloroformate (6)	Bulk	4	2	105	0.35	0.7
8014-95-7	Oleum 65% SO_3 (8) (9)	Bulk	160	35	220	0.02	0.6
7664-39-3	Hydrogen fluoride	Cylinders (2)	50	2	816	0.21	0.5
7719-12-2	Phosphorus trichloride (6)	Bulk	15	2	100	0.09	0.2

(1)Bulk packs up to 5000 gallons

(2) Also in bulk trucks

(3) Bulk trucks normally 5000 gallons for liquids

(4) (Vapor pressure in mmHg) x 10 / (ERPG 3 as ppm) x 760 mmHg

(5) Not on RPM list

(6) Estimated shipping volume equivalent to Hydrogen Fluoride 4.6

Highest-Priority TICs

- Top three (rail and truck) for transportation are chlorine, sulfur dioxide, and ammonia (anhydrous) – all are stored and shipped as pressurized liquified gases and have low boiling points
- Others in this group are chlorine trifluoride, hydrogen chloride (anhydrous), hydrogen fluoride, and phosgene
- Others that are liquids at ambient pressure are acrolein, bromine, hydrogen cyanide, and methyl chloroformate
- Two fuming liquids – oleum (65 % sulfur trioxide) and phosphorus trichloride

Flammables of Concern

- Propane (most prevalent)
- Butadiene (involved in several big accidents)
- Hydrogen
- Ethylene oxide
- Propylene oxide

Note shallow yellow chlorine cloud

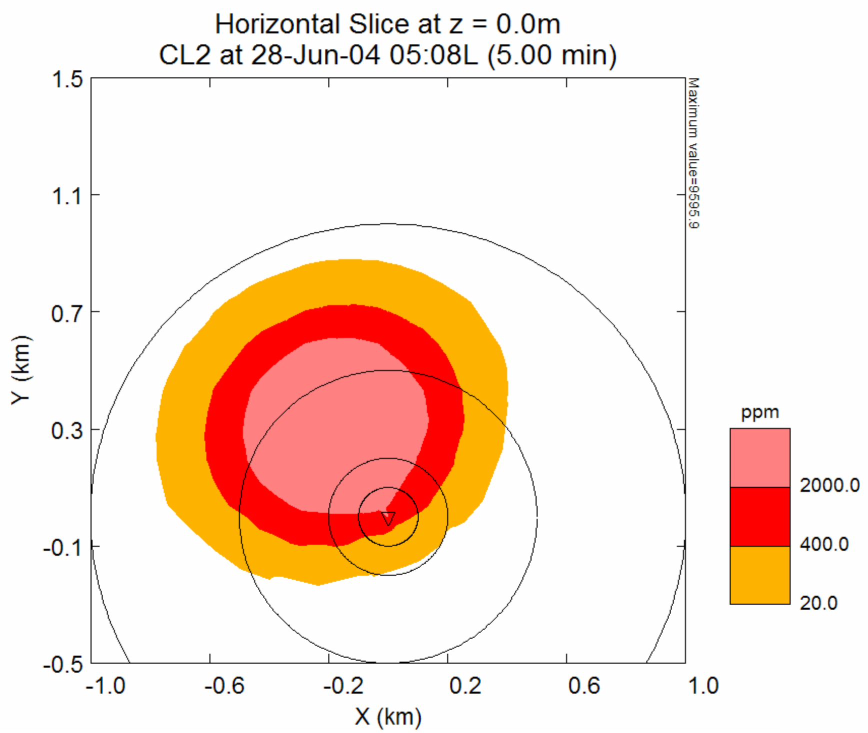
Festus, Mo

Source: US Chemical Safety and Hazard Investigation Board

Macdona, TX

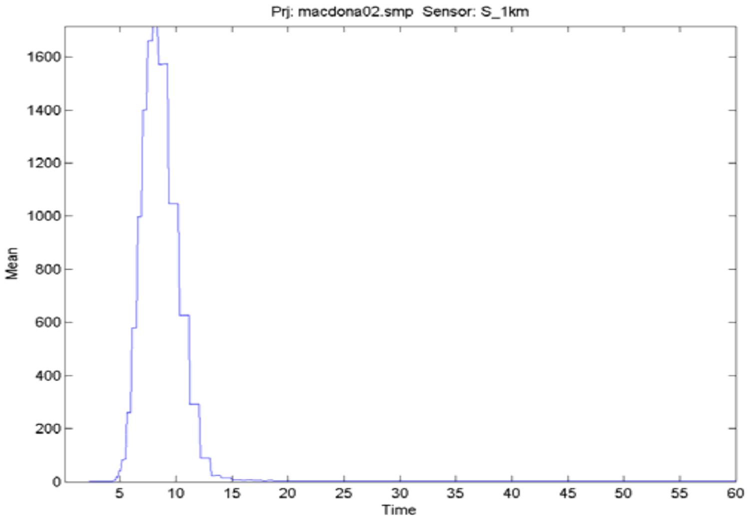
Photos of Graniteville, SC, Train Wreck

Photos Courtesy of Augusta Chronicle



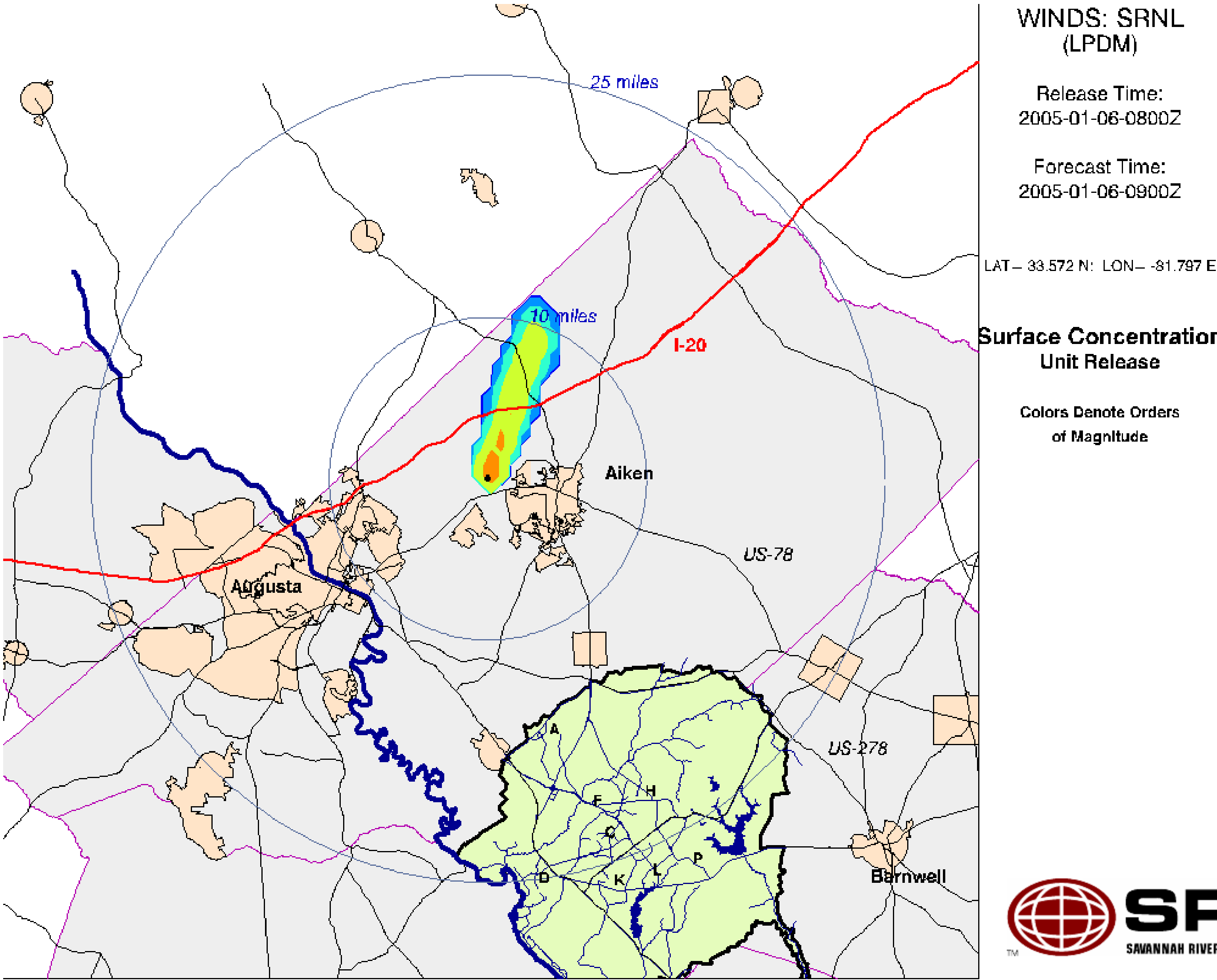
SCIPUFF OUTPUTS FOR MACDONA

CONTOURS AT 5 MINUTES AFTER RELEASE



CONCENTRATION TIME SERIES AT X = 1 KM

Graniteville, SC, initial plume predictions by Savannah River Lab model (no dense gas effects)



SRNL
SAVANNAH RIVER NATIONAL LABORATORY

Six Models Applied to Three Railcar Accidents

- SCIPUFF, SLAB, HGSYSTEM, ALOHA, TRACE, PHAST
- Models generally agree within a factor of two on plume parameters, assuming all are given the same source
- Max concentrations as a function of downwind distance
- Max distance to 20, 400, 2000 ppm
- Width and depth of plume to 20, 400, 2000 ppm
- For large releases (Macdona and Graniteville), the simulated cloud is 40 times as wide as it is deep, due to dense gas effects

Emergency Response Guidance based on Experiences with Recent Railcar Accidents

- Assume that a significant fraction of the railcar contents is released (in the range from about 10 to 90 tons).
- A dense cloud is formed that consists of a mixture of gas and small aerosol drops. The drops soon evaporate. The gas cloud is visible (see the photo of Festus).
- The dense cloud initially spreads in all directions (even upwind) due to dense gas slumping and will follow terrain slopes.
- The dense cloud is shallow (1 or 2 m deep) and is much broader than passive clouds.
- After a few 100 meters of travel, the cloud starts behaving more like a passive (neutral) plume. The distance is larger for releases from large holes, such as Graniteville.

Emergency Guidance, Continued

- Pockets of toxic gas can remain for a while in low-lying areas and behind buildings Persons who are outside should stay away from low-lying areas
- Usually, after the initial large emission rate lasting an hour or more, there is a smaller emission rate that lasts for several hours, or until the hole is plugged
- Because of the shallow nature of the dense cloud, persons in buildings near the release location should shelter in place in the upper stories of the buildings
- HVAC inlets on the first floor should be shut off
- Persons should realize that the cloud will be very broad in area

Review of Source Emissions Formulas and Models and Recommendations

Started with AIChE/CCPS 1996 Guidelines Book by Hanna, Drivas, and Chang

Added more recent papers and books and experience

Three main categories:

- Evaporation from liquid pool
- Gas jets
- Two phase jets from pressurized liquified gas

Most releases are time-variable and finite duration (i.e., the tank empties)

The two-phase category is the highest priority but is the most poorly-known

Need for a Thermodynamic Package

- The user has to be able to determine if the TIC is a gas or liquid and properties such as temperature and density when it is at ambient pressure
- Several software packages are available from the chemical industries and govt agencies
- A thermodynamics software package from NIST is recommended

Simple basic equations are valid for some types of releases, such as a pressurized ideal gas released through a simple small opening in the tank

If this choked flow condition is met, for an ideal gas exiting through an orifice under isentropic conditions, the gas emission rate will follow the critical flow relationship (Perry *et al.*, 1984), which is independent of downstream pressure:

$$Q = c_o A_h \left(\gamma \rho_p p \left(\frac{2}{\gamma + 1} \right)^{\frac{\gamma + 1}{\gamma - 1}} \right)^{1/2} \quad (4\text{-}2)$$

where

Q	= time-dependent gas mass emission rate (kg s-1)
c_o	= discharge coefficient for orifice (dimensionless)
A_h	= puncture area (m2)
ρ_p	= gas density in tank (kg m-3)
γ	= c_p/c_v (ratio of specific heats for gas)

Flashing is important for pressurized liquified gases such as Cl_2. When the liquid is released, a fraction of it becomes a gas and the following formula can be used to calculate the fraction

For a single component and a constant temperature, this heat balance yields a simple expression for the fraction of liquid flashed:

$$\frac{Q_f}{Q_l} = \frac{c_p (T - T_b)}{H_{vap}} \qquad (4\text{-}14)$$

where

Q_f = mass emission rate of liquid that flashes (kg s^{-1})
Q_l = total liquid mass emission rate (kg s^{-1})
c_p = heat capacity of the liquid (averaged between T and T_b) (J kg^{-1} K^{-1})
T = temperature of the liquid in the tank (K)
T_b = normal boiling point of liquid (K), assumed lower than T
H_{vap} = heat of vaporization of the liquid (J kg^{-1})

A big question is whether the unflashed liquid (85 % of the total mass for Cl_2) forms a pool on the ground or remains in the air as small drops

Task 3 – Survey of related field experiments and recommendations of new experiments to fill data gaps

- A comprehensive list of 35 field experiments was tabulated, including overviews of the details of each experiment. To identify critical gaps, the characteristics of each experiment were compared. This material has been taken, with permission, from the Joint Effects Model (JEM) field experiment survey and gap analysis report.

- Beginning with the above list, a subset of field experiments were identified that involved source emissions issues (such as the Desert Tortoise anhydrous ammonia tests).

- Additional recent field experiments that focused on two phase releases were summarized. These include the FLADIS, URAHFREP, FLIE, and RELEASE experiments.

- Data gaps were identified and recommendations made for future field experiments The highest priority data need concerns two phase releases (of pressurized liquid gases such as chlorine, anhydrous ammonia, and sulfur dioxide) from typical railcar and tank truck scenarios.

CCPS/AIChE Sponsored Field Experiments with Releases of Pressurized Liquified Gases

Table 6-3 Characteristics of CCPS/AIChE Releases of Chlorine, Methylamine, and Cyclohexane at Nevada Test Site

	Chlorine	Methylamine	Cyclohexane
Number of tests	22	18	22
Boiling point, K	236	254	338
Temperature, K	245-289	270-296	338-398
Liquid superheat, K	9-53	6-31	0-48
Pressure, psia	21-142	171-560	140-556
Orifice diameter. mm	6.35	6.35	6.35-12.7

Conclusions

- Highest-priority releases are chlorine, sulfur dioxide, and ammonia (anhydrous)
- These lead to dense clouds that are shallow and wide
- Source emissions models are least-developed for this category of release
- Field data gaps exist, especially for large two-phase releases

Micro SWIFT/SPRAY (MSS)

Presentation to:

Chemical Biological Information Systems Conference

January 2007

Tom Harris, C. Dougherty, J. Sontowski, SAIC

(harrist@saic.com)

Jacques Moussafir, Julien Commanay, ARIA Technologies

(jmoussafir@aria.fr)

Agenda

- **Micro SWIFT/SPRAY Overview**
- **Joint Urban 2003 Simulations**
  - IOP2 and IOP8
- **MSS Integration in HPAC**
- **Summary**

Problem Statement

- One of JSTO's 'Early Warning' Thrusts:
  - ***"CBRN Hazard Prediction in Complex Urban Terrain with Near-real Time Accuracy"***

- M&S challenges for urban simulations include:
  - Extensive structural databases and interfaces
  - Complex flow patterns
  - High resolution modeling requirements

Micro SWIFT/SPRAY Solution

- The wind field solver, MicroSWIFT, is an adaptation of SWIFT, a mature, well validated mass consistency model

- MicroSWIFT is designed to handle urban topography, length scales, and flow features.

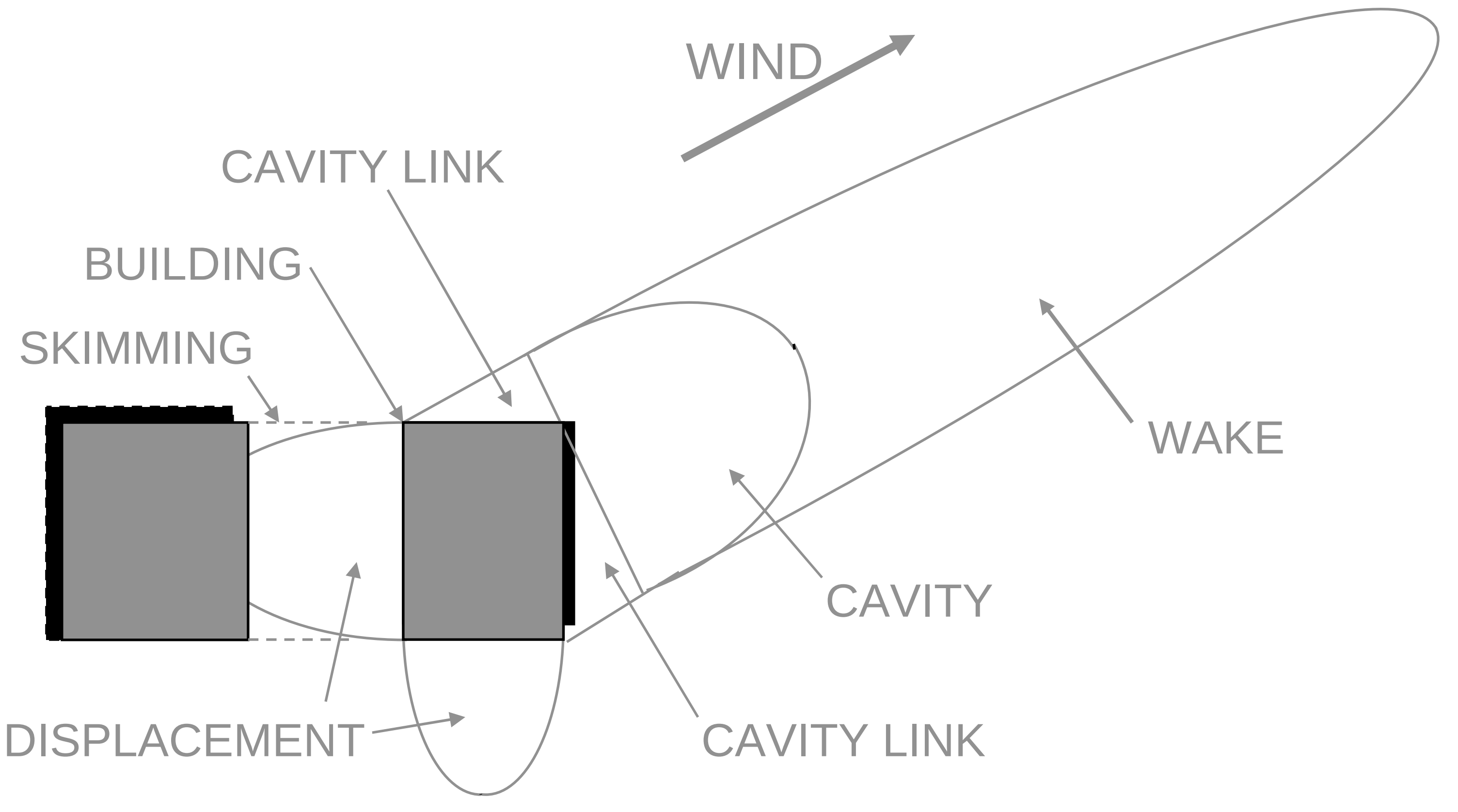
- Particle transport is modeled using a Monte-Carlo Lagrangian technique, MicroSPRAY.

Micro SWIFT /SPRAY Elements

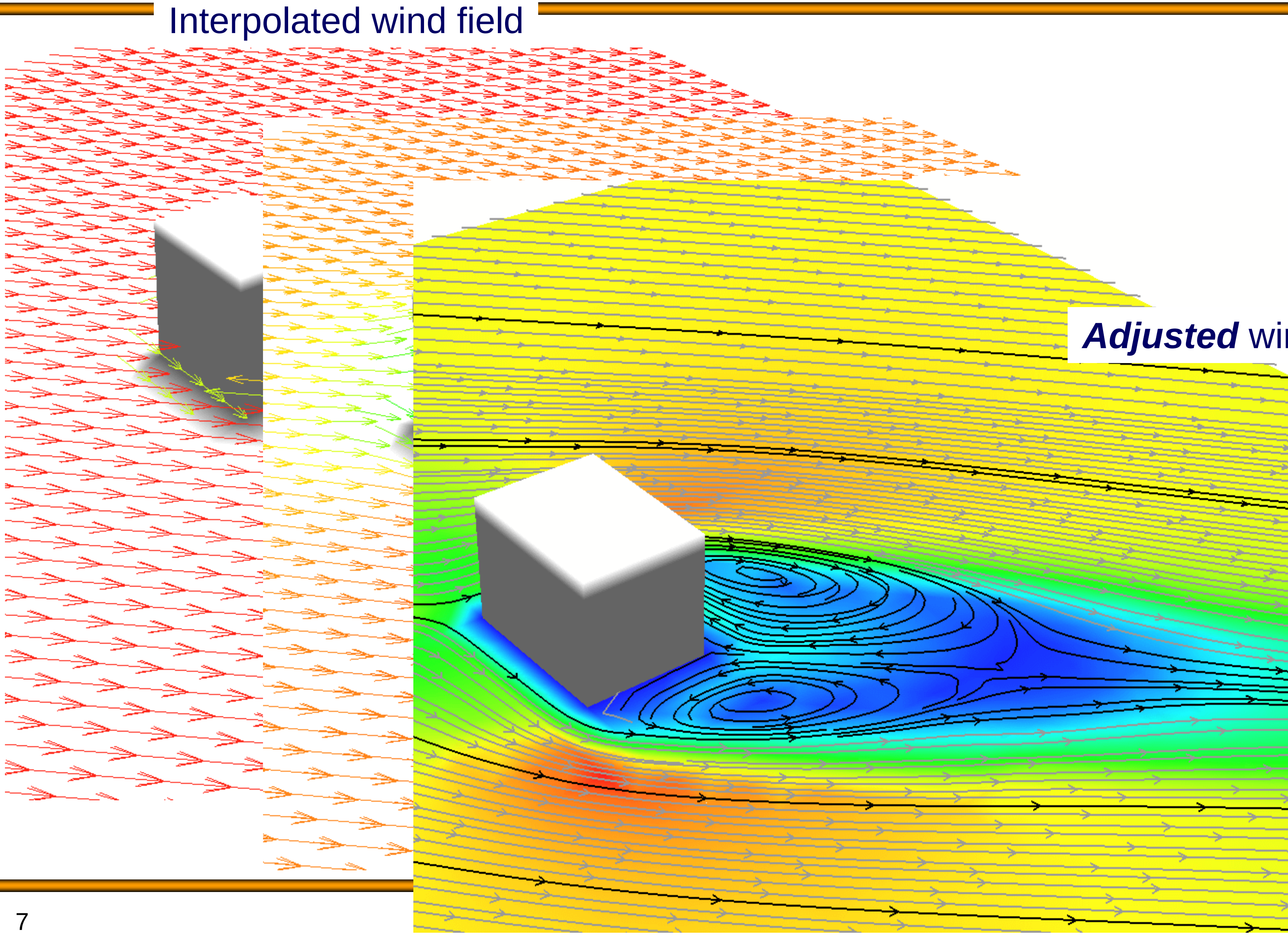
- **Exact representation of buildings**
- **Initial estimate of 3D mean flow from SWIFT, driven by available meteorological data**
- **Analytical corrections for flow about obstacles**
- **Entire flow field is iteratively updated to satisfy mass consistency**
- **Dispersion simulated using a Monte-Carlo Lagrangian technique**

Urban SWIFT Wind Field Construction

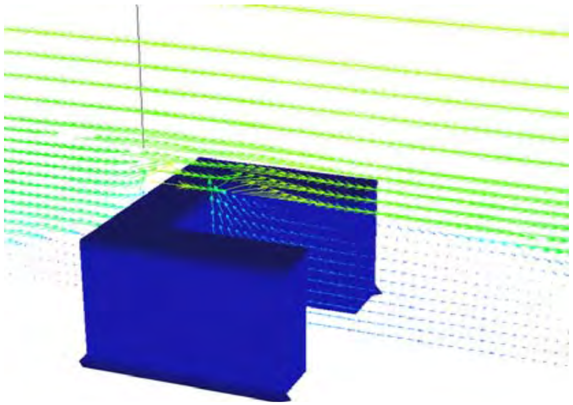
Typical Objects - Building and Flow Zones:



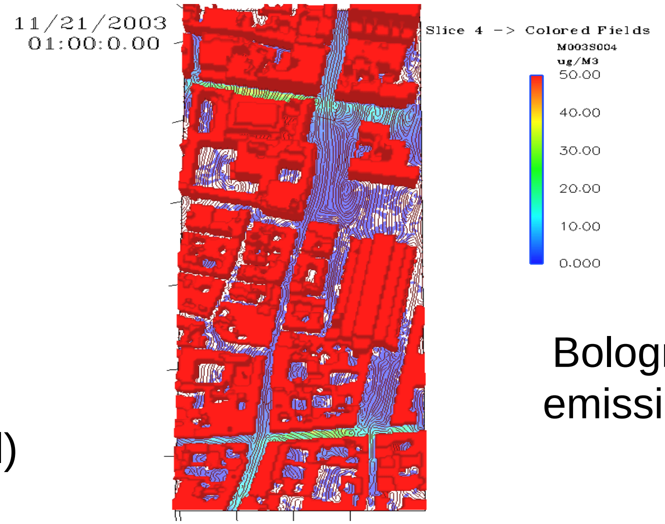
Micro SWIFT Steps



Primary MSS Validation Cases



U-shaped Building (Kastner-Klein, et al)



Bologna traffic emissions study

- **U-Shaped Building (Wind tunnel data)**
- **L-Shaped Building (Wind tunnel data)**
- **Salt Lake City "Joint Urban 2000" (Field Experiment)**
- **Oklahoma City "Joint Urban 2003" (Field Experiment)**
- **Bologna, Italy (Field Experiment)**

Agenda

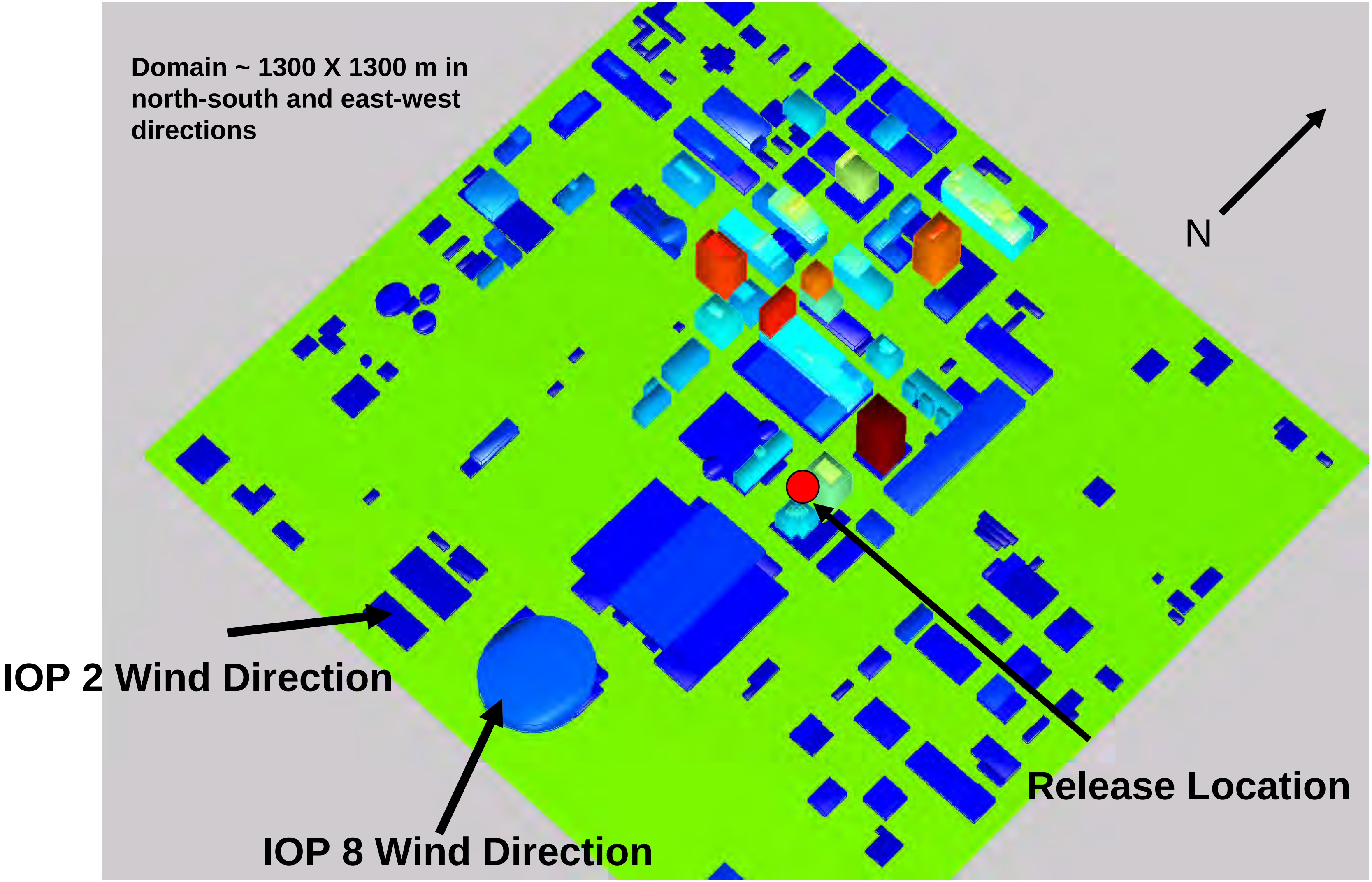
- **MSS Overview**
- **Joint Urban 2003 Simulations**
  - IOP2 and IOP8
- **MSS Integration in HPAC**
- **Summary**

JU 2003 Simulations

- **The JU2003 Field Data provides a unique database for the evaluation of urban dispersion models.**

- **Selected IOPs are the basis for an intercomparison of diagnostic urban wind field models**
  - See paper by John Hannan et al.

Urban Model Domain for JU2003



JU2003 IOP Comparison

- **IOP2*** (2 July 2003)
  - Westin release (Daytime)
  - SW winds
  - 3 CRs (5 g/s)

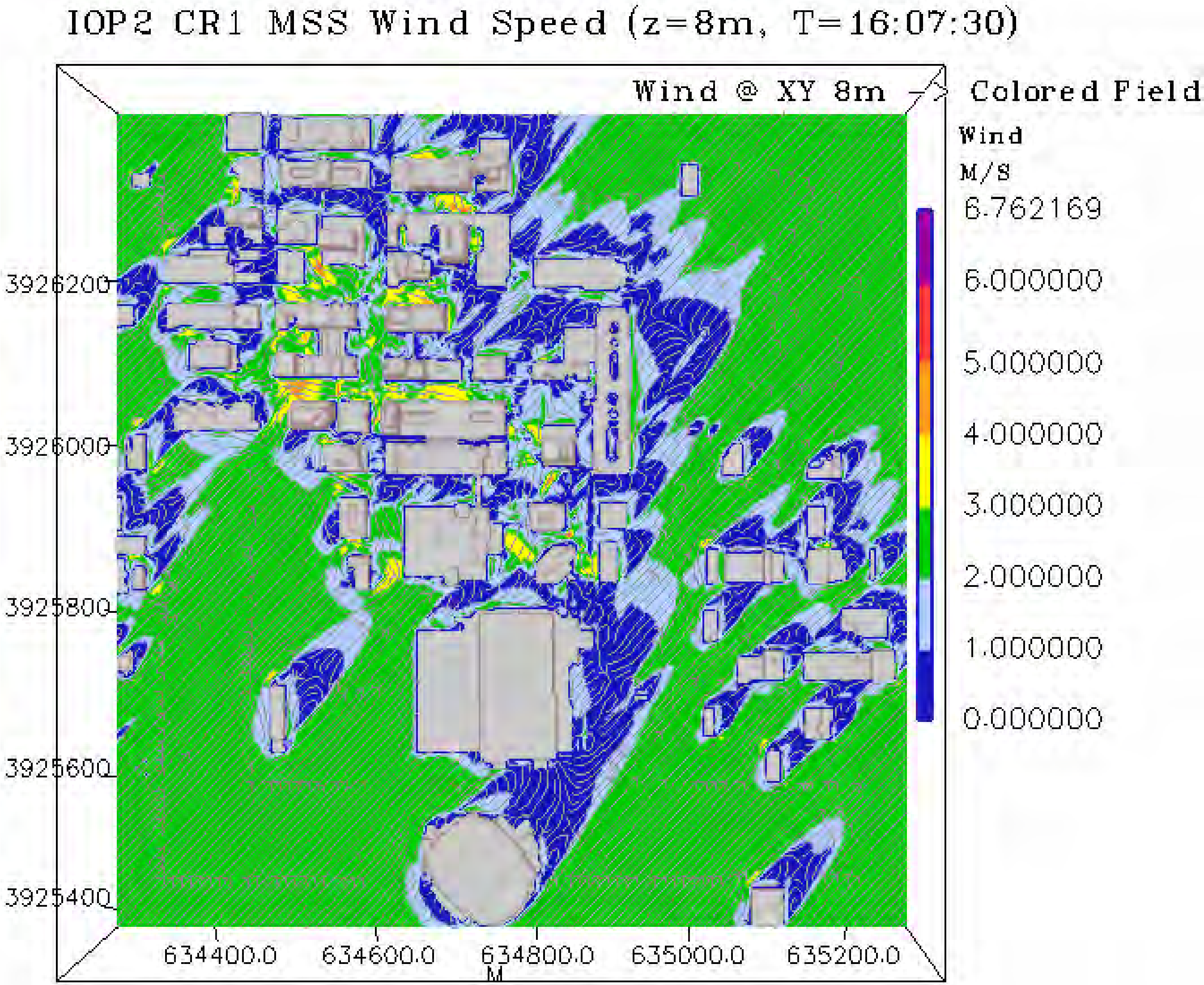
- **IOP8*** (18 July 2003)
  - Westin release (Night)
  - Southerly winds
  - 3 CRs (3 g/s)

**IOP used for comparison of Rockle-based models*

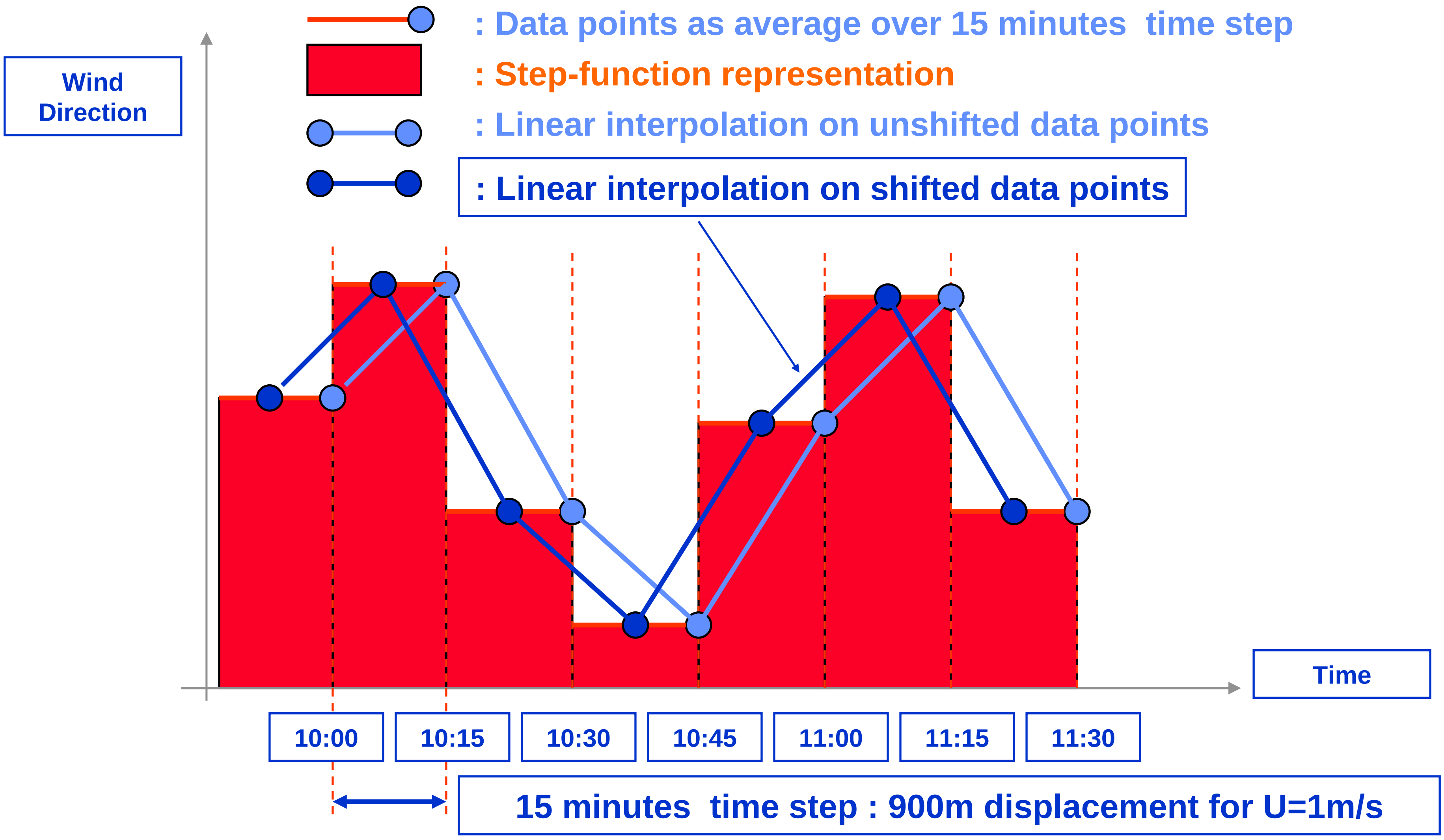
MSS Predictions for JU2003 IOP2

- OKC JU2003 IOP2 Test Conditions
  - Date: July 2, 2003
  - Release location: Westin
  - Continuous releases/times examined:
    - *CR1/1000-1030CST*
    - *CR2/1200-1230CST*
    - *CR3/1400-1430CST*
  - Met data input to MSS: PNNL Sodar
  - MSS computation domain (see slide)
    - *domain size: ~1km square*
    - *horizontal resolution: 4m X 4m*

MSS Wind Speed at h = 8 m



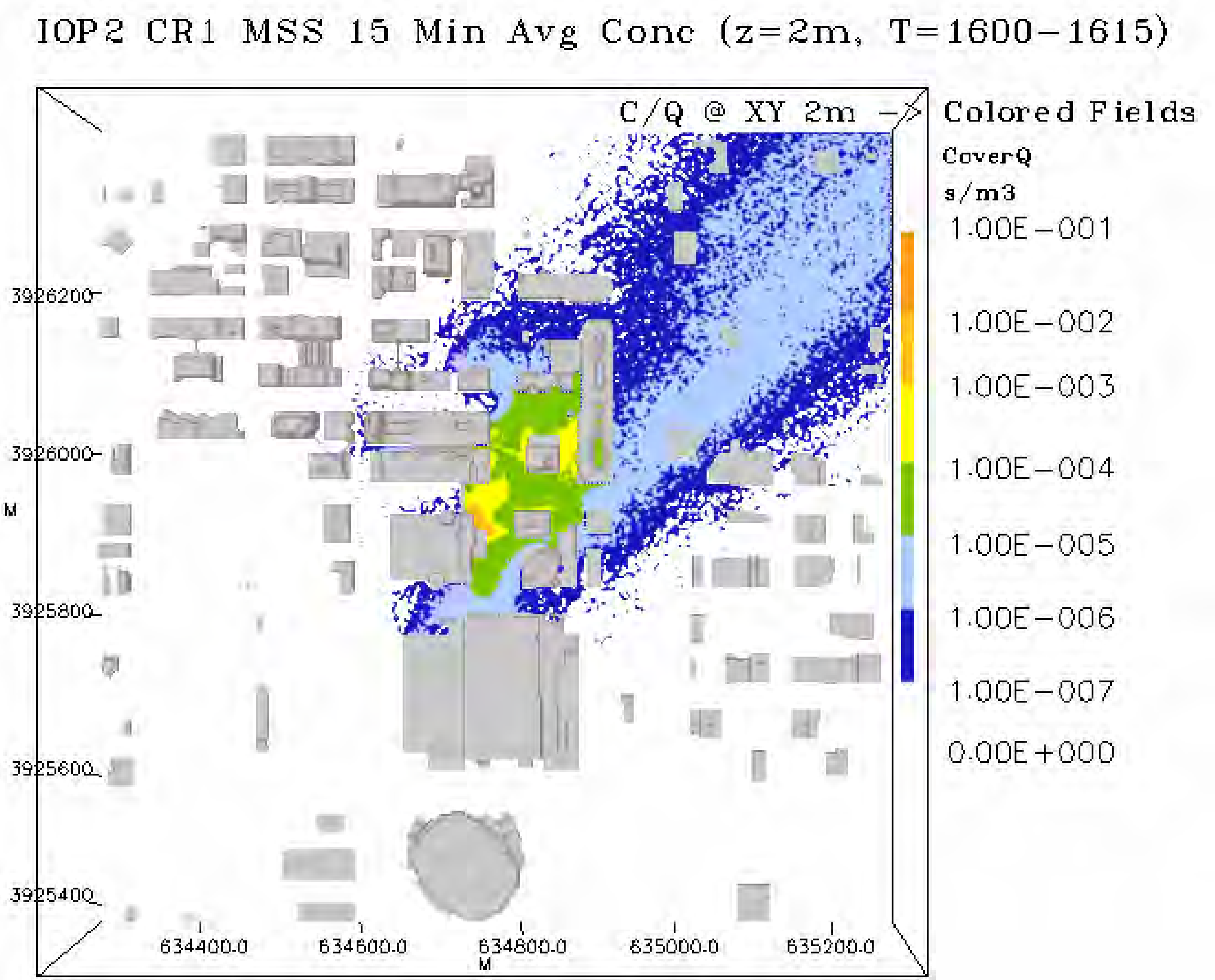
Need for high-resolution in time in the MET input for MSS



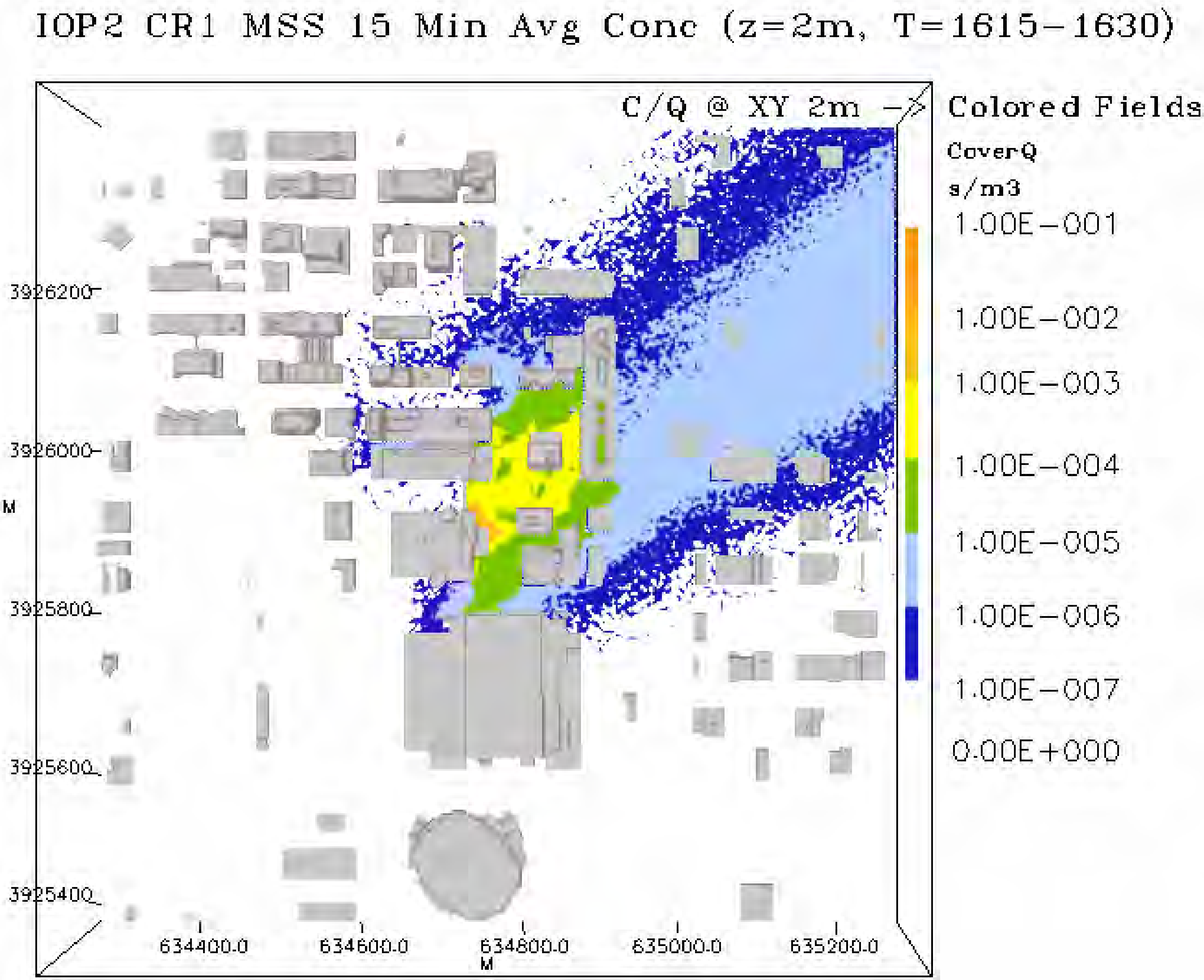
Issues regarding the averaging periods and HPAC/MSS inputs

- Long term averages for wind inputs:
  - Can lead to unrealistic results, especially when the winds are variable over the 15 minute averaging period.
  - Particularly important for microscale modeling.
  - SWIFT and MSWIFT within HPAC interpolate between solutions at instantaneous times. Preferred approach is to assign wind average to mid-point of averaging interval and interpolate between interval mid-points.
  - Realism is improved with shorter averaging periods.
  - MSS computational efficiency allows, and microscale in some cases requires, real time calculations for averaging periods of 15 minutes or less.

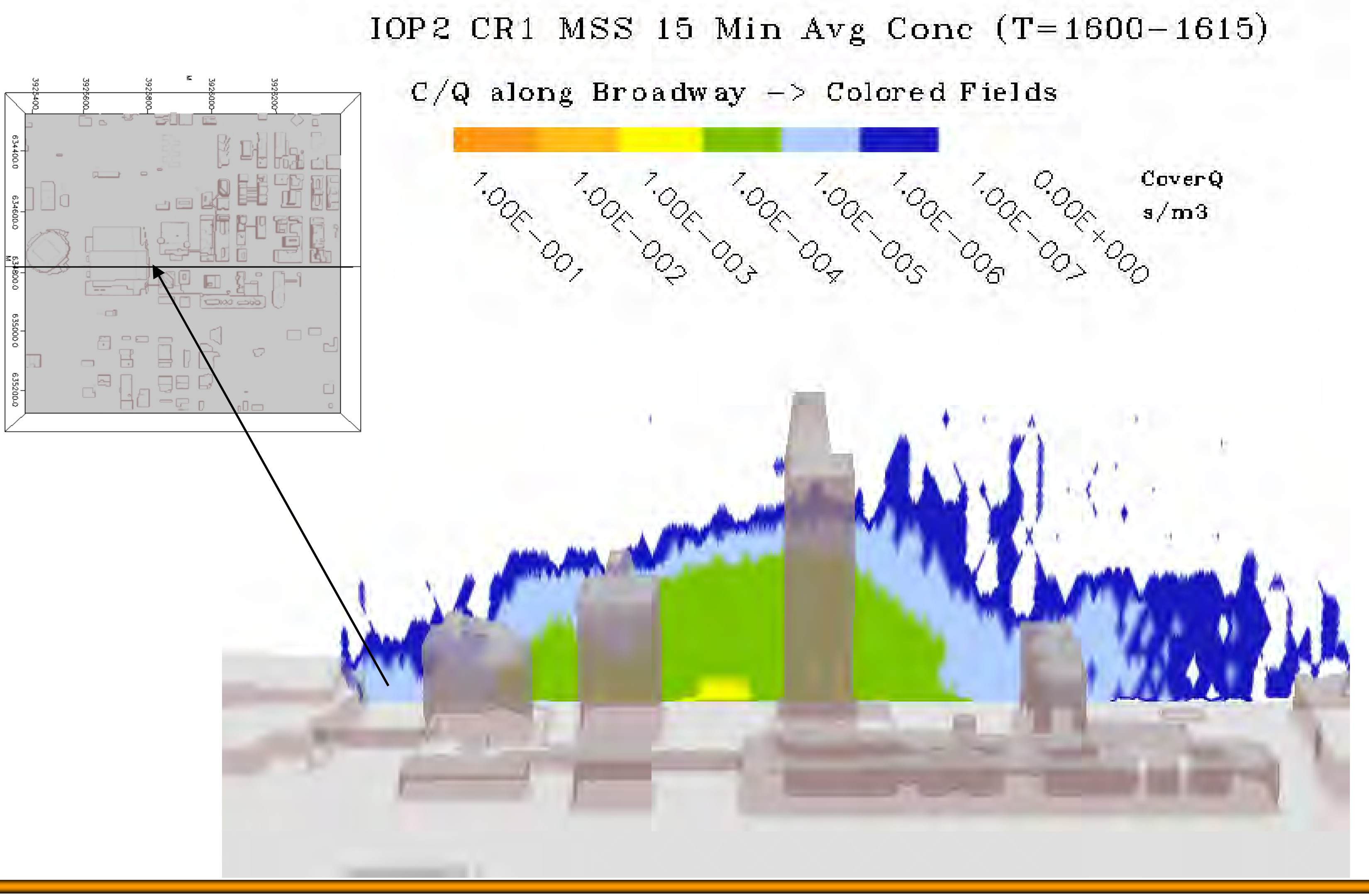
IOP2 Concentration Contours



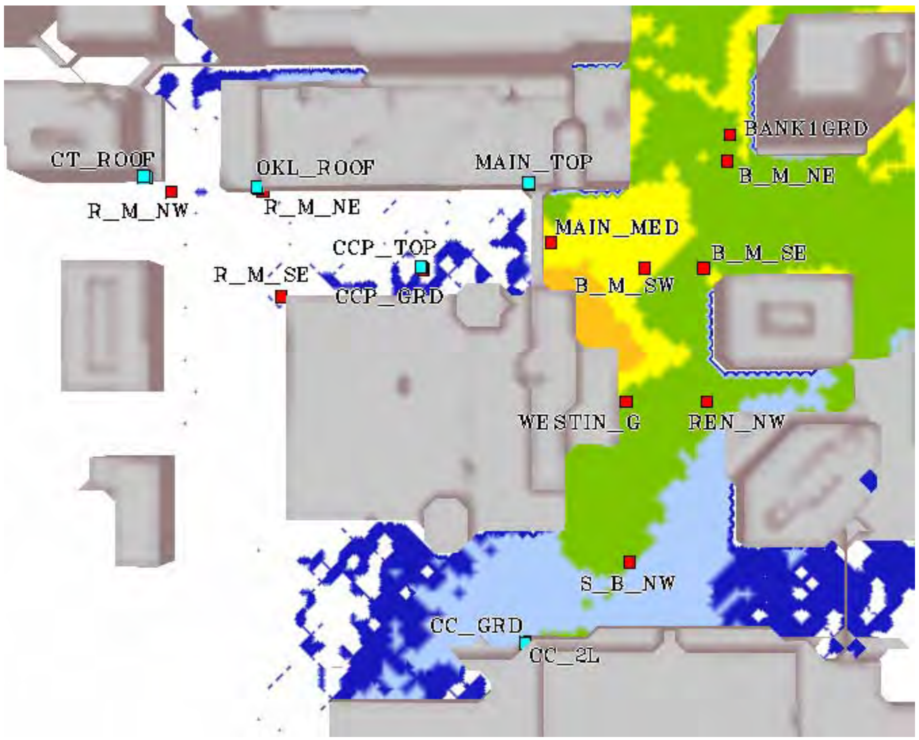
IOP2 Concentration Contours

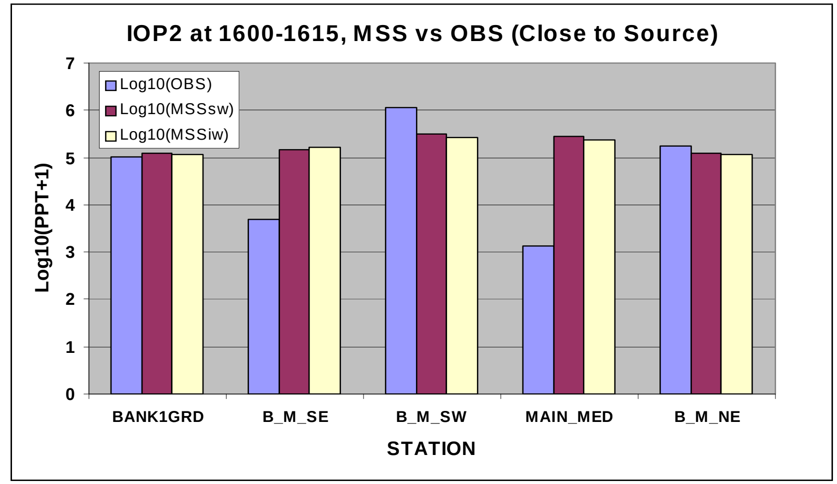


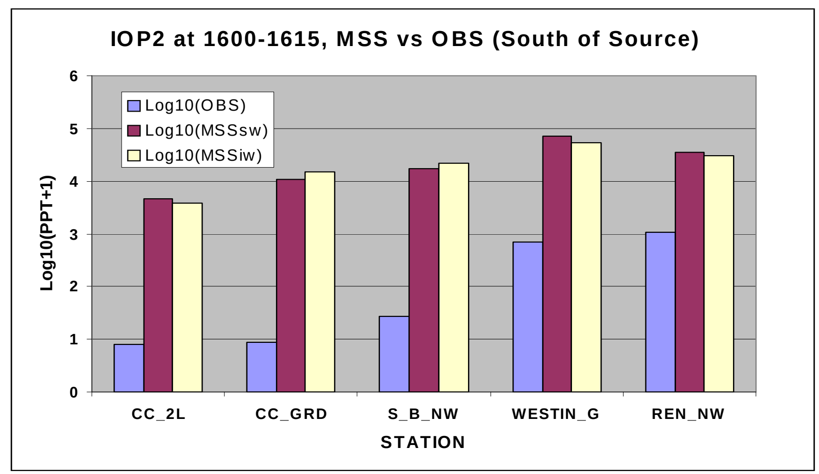
Vertical Concentration Profiles



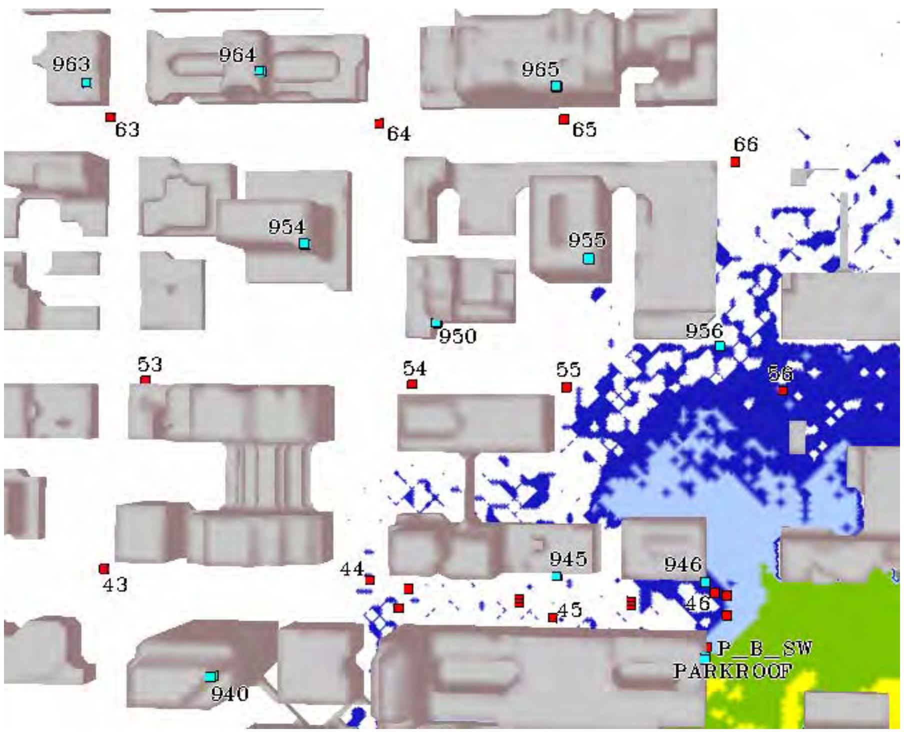
Comparison of Concentration Predictions with Sampler Data

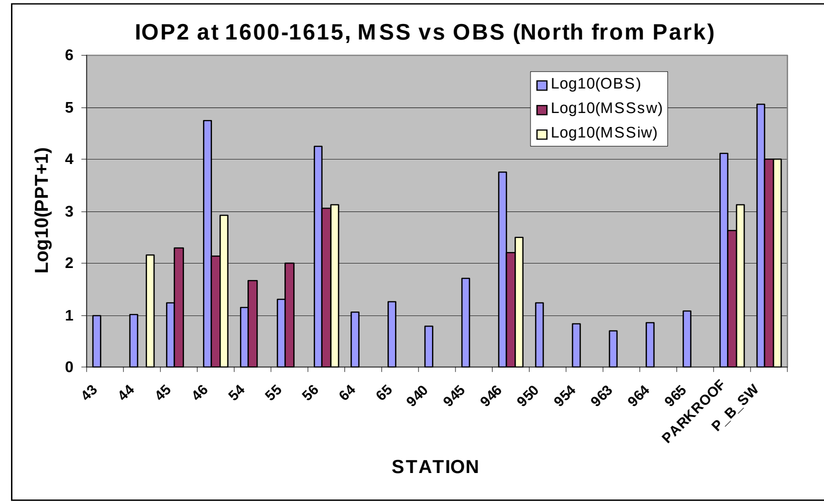


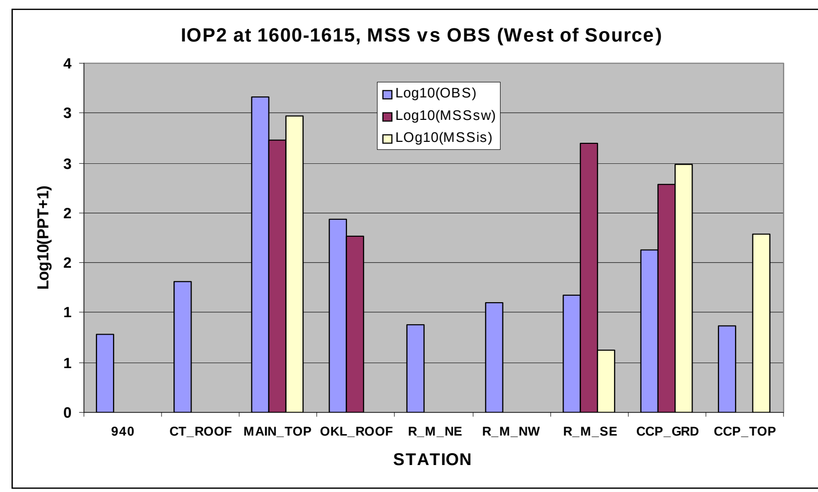




Comparison of Concentration Predictions with Sampler Data







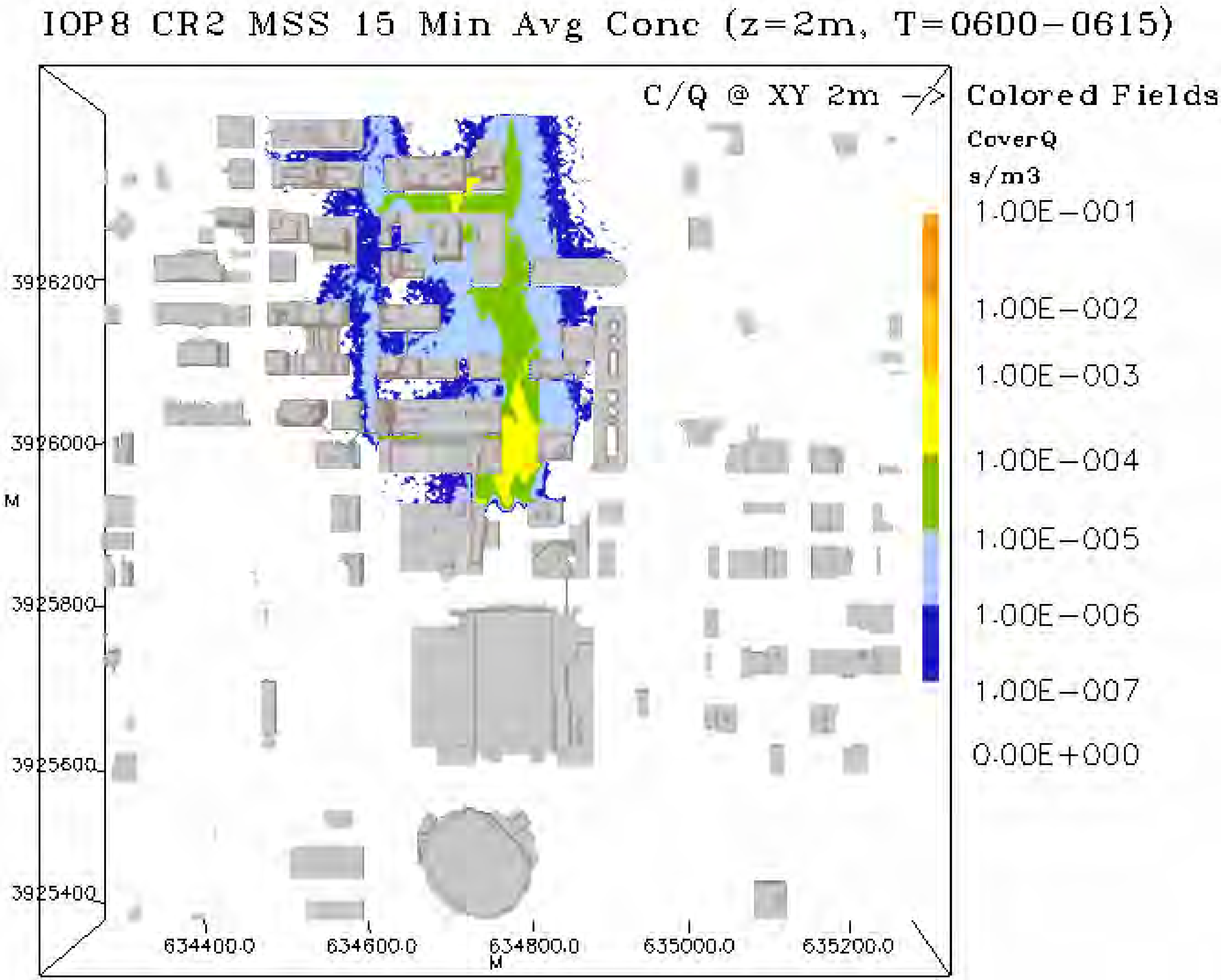
MSS Simulations for JU2003 IOP8

- OKC JU2003 IOP8 Test Conditions
  - Date: July 18, 2003
  - Release location: Westin
  - Met data input to MSS: PNNL Sodar
  - MSS computation domain (see slide)

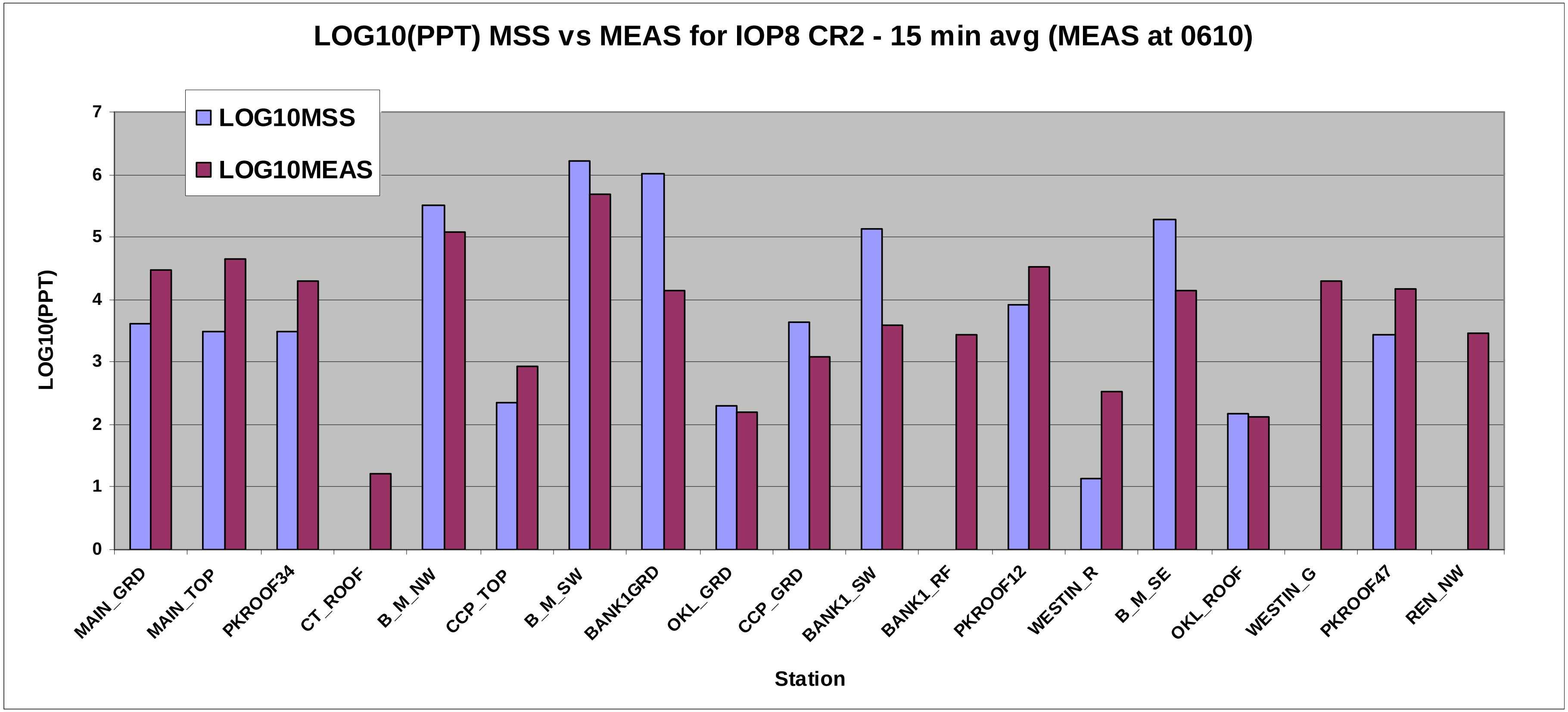
    - domain size: 1km square

    - horizontal resolution: 4m X 4m

IOP8 Concentration Contours

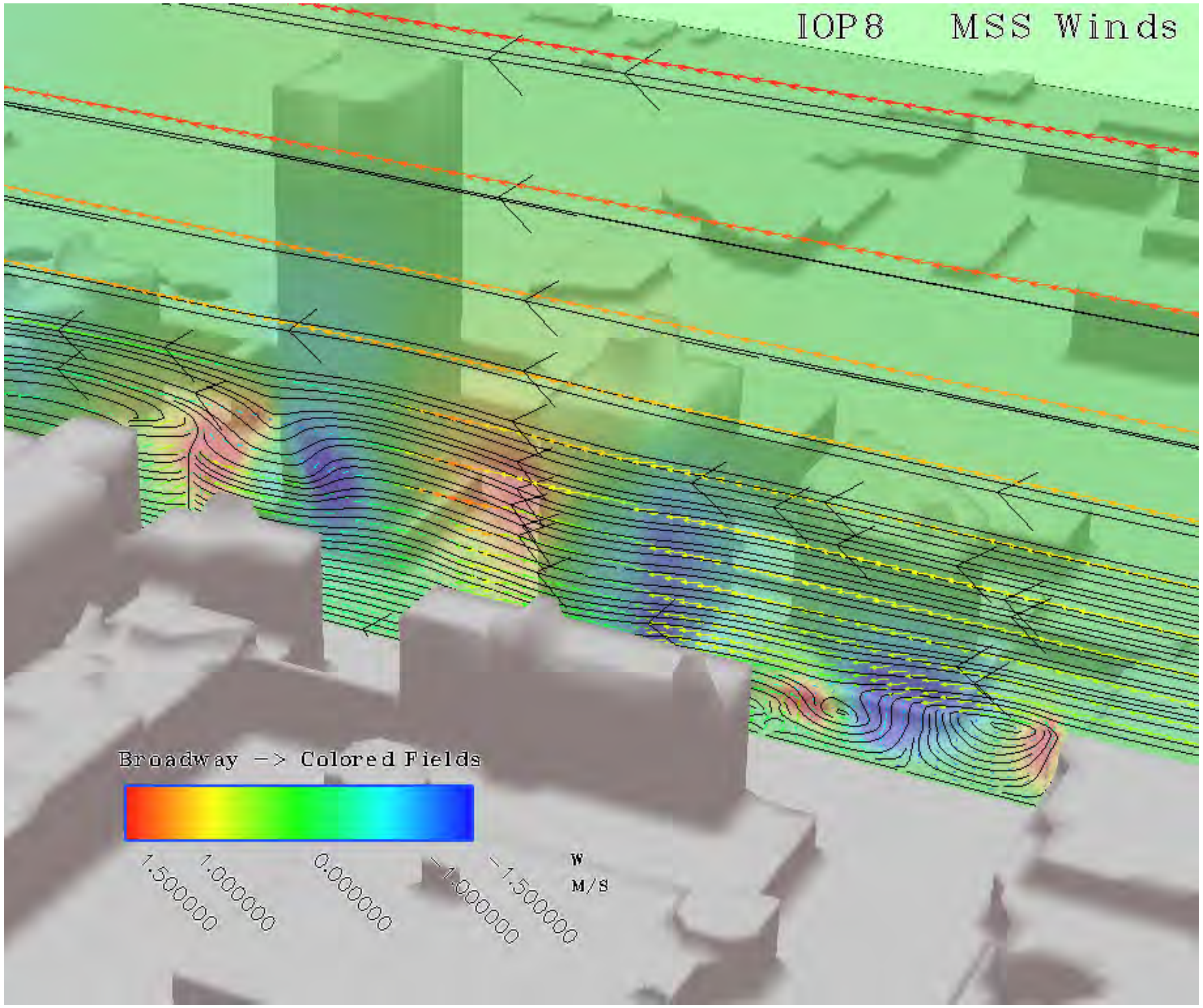


Comparisons with Selected Tracer Instruments

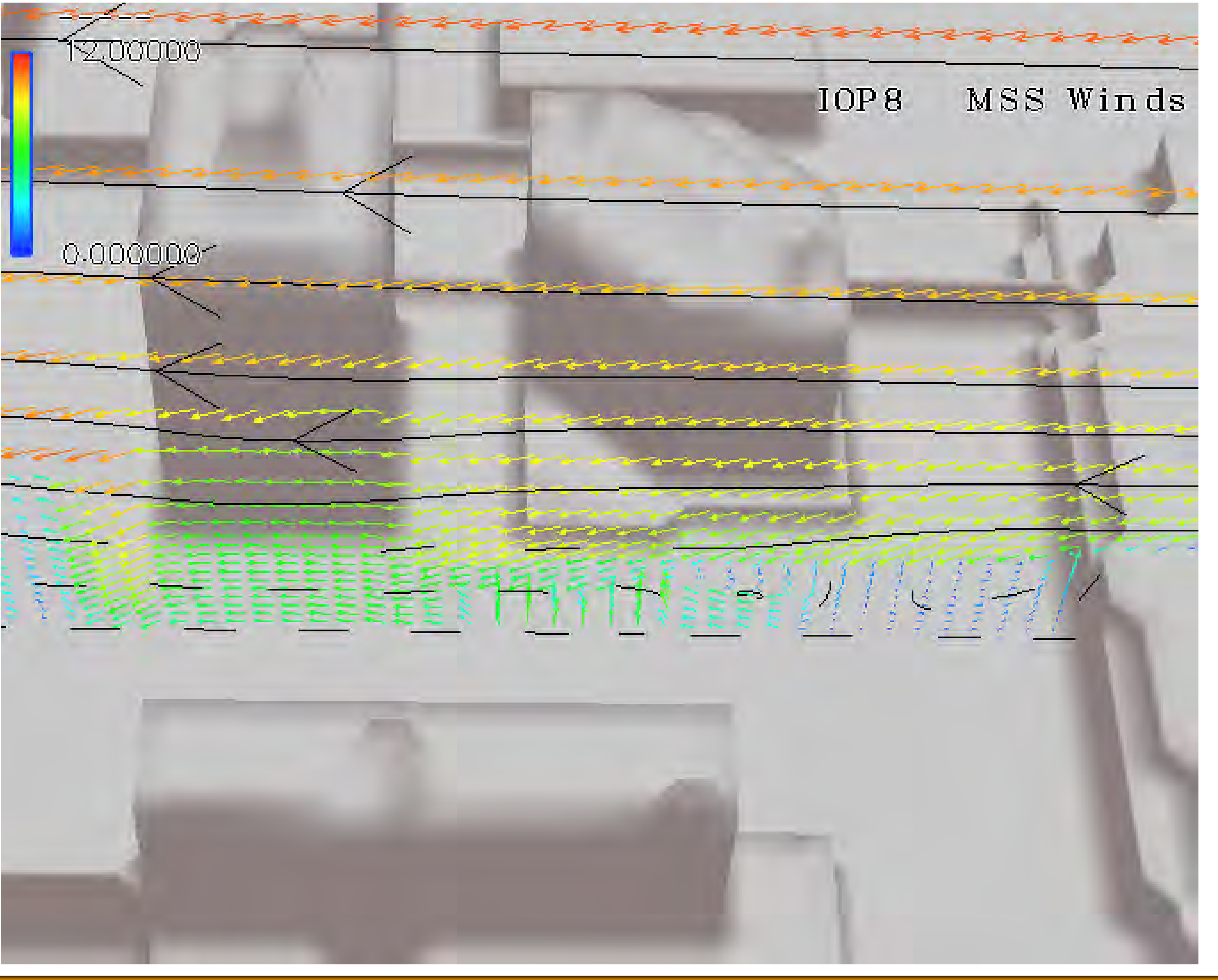


- **Data indicates upstream advection (e.g. at Westin_G and Ren_NW) that MSS does not predict.**
- **Sensitive to relative position of reattachment and release points.**

Velocity Vectors along Broadway for IOP8



Velocity Vectors along Broadway



Agenda

- MSS Overview
- Joint Urban 2003 Simulations
  - IOP2 and IOP8
- **MSS Integration in HPAC**
- Summary

MSS – HPAC Interface
MSS Input Provided by HPAC

- **Domain – 640 m^2 to 1 km^2 @ 3, 4, or 5 m resolution, centered on the release location**
- **Meteorology – profiles extracted from the larger domain SWIFT mass consistent wind field, which can be based on:**
  - Observations – surface and/or upper air
  - Gridded output of NWP models (in MEDOC format)
  - Historical data (AFCCC climatology)
  - Fixed winds
- **Terrain/land use – interpolation of the HPAC DTED level 0 (1 km) and LandScan databases**
- **Urban structures – triangulation of Shapefiles obtained from GEDIS (Geographic and Environmental Database Information System)**
- **Release – type, location, amount, duration, material properties**

MSS – HPAC Interface
MSS Output Provided to HPAC

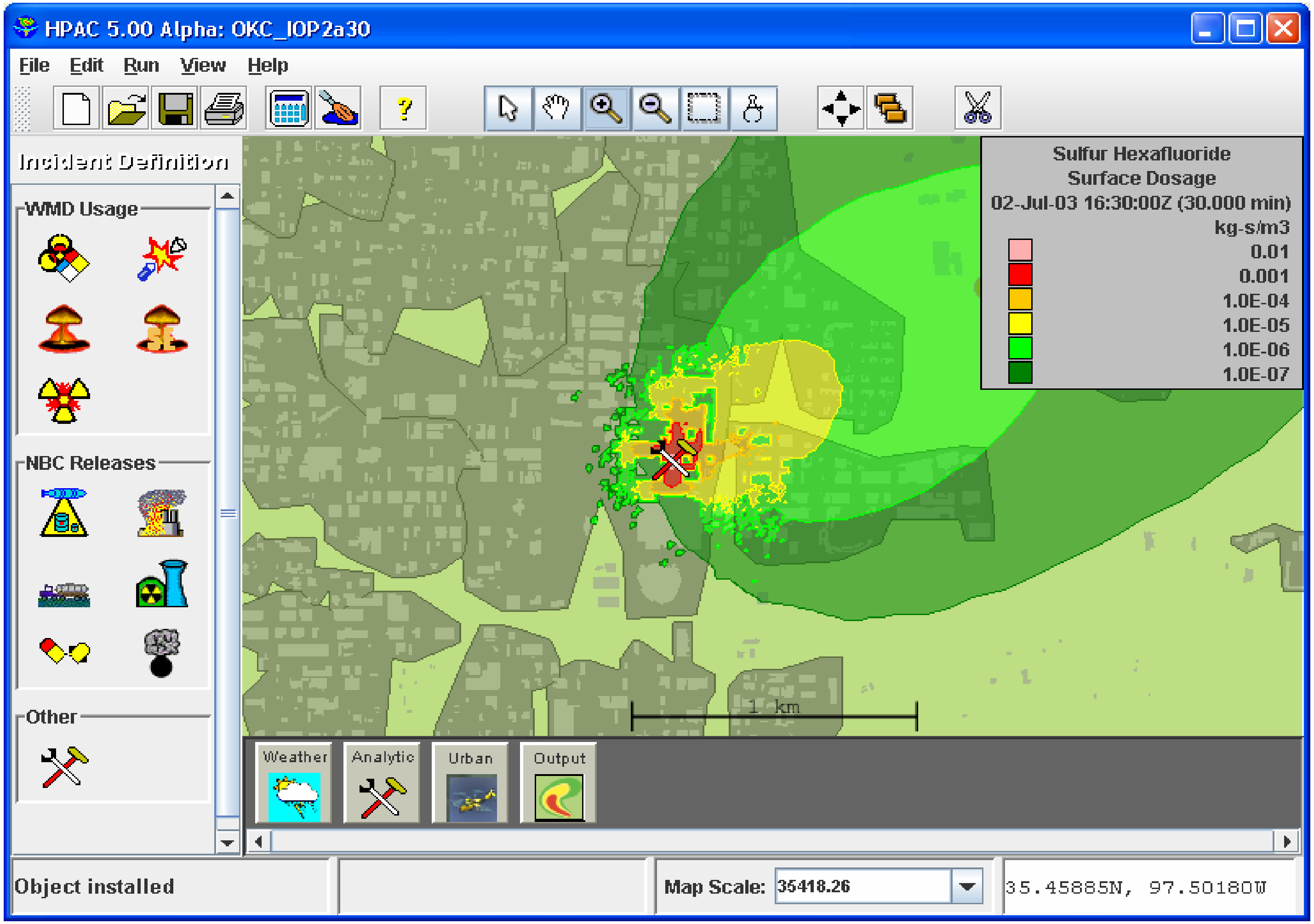
- **Puffs – created by aggregating particles as they leave the MSS domain, at specified synchronization times**

- **Plot quantities inside the MSS domain**
  - Surface dosage
  - Surface concentration
  - Concentration slices
  - Vertically integrated concentration

- **3D wind and turbulence fields at specified times**
- **3D concentration and surface dosage fields at specified times**
- **Concentration values at specified locations (samplers) at specified times**

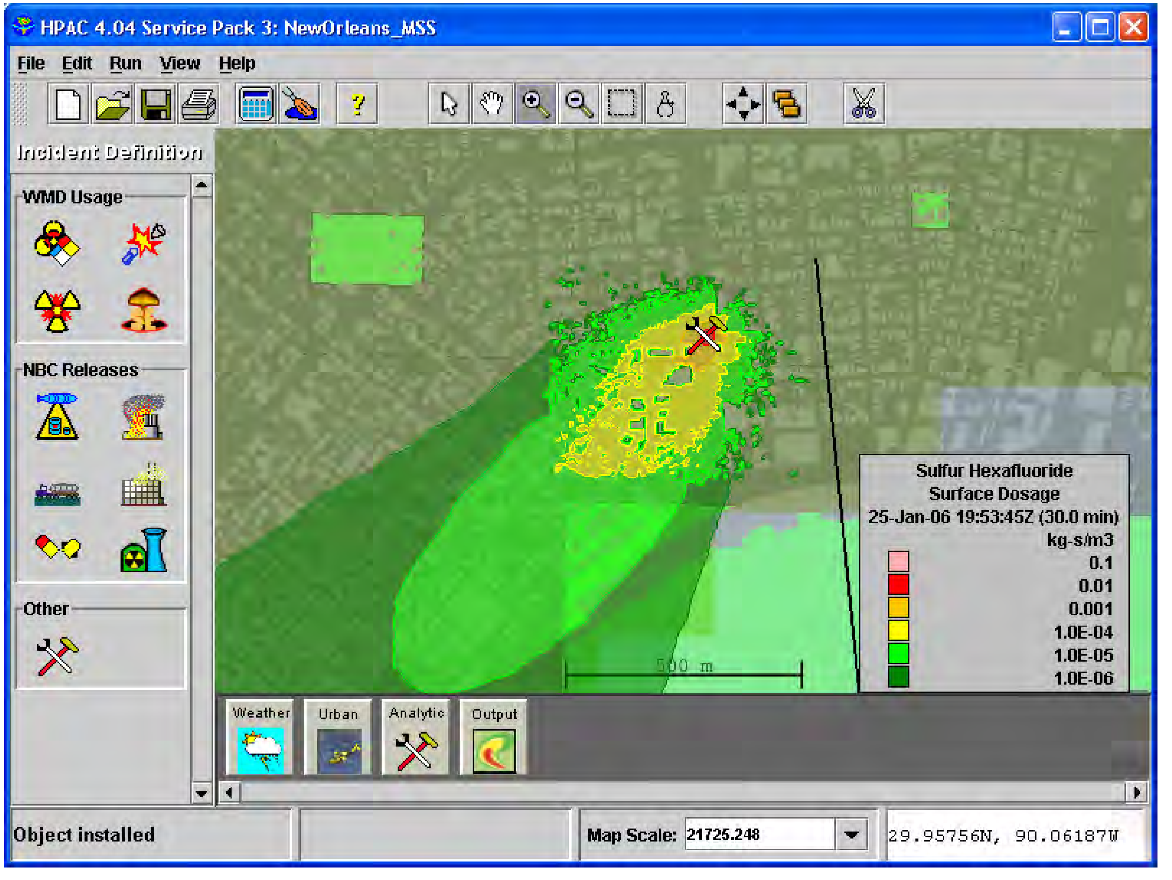
HPAC 5.00- Oklahoma City

Met: PNNL profile; Domain: 1 km @ 4 m



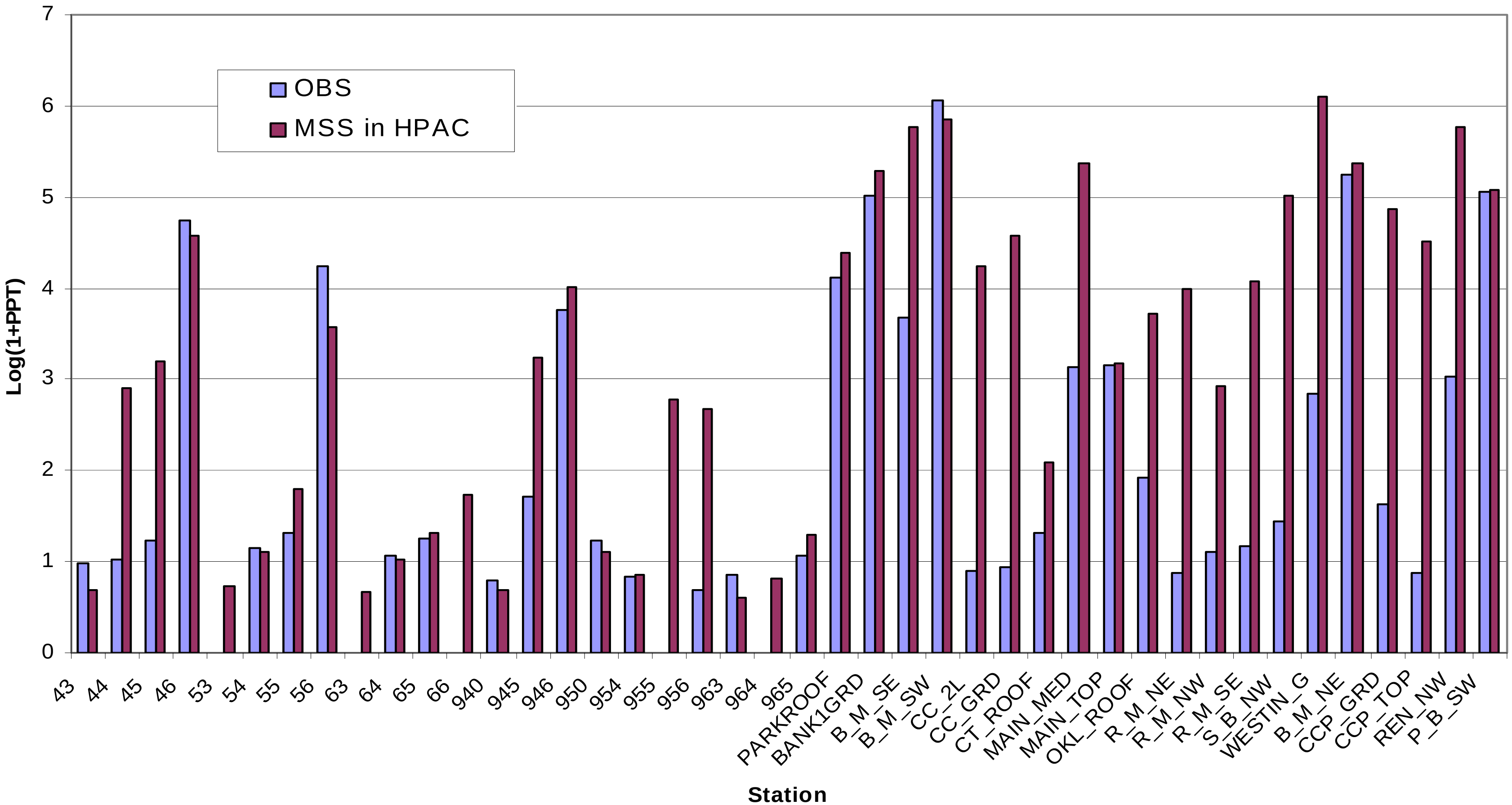
MSS: New Orleans

Met: fixed winds (MSWIFT at 0 min); Domain: .8 km @ 5 m; Runtime: 5 min.



MSS/HPAC Predictions

IOP2 CR1 t=1615



MSS applications in France

CEA-DAM **is the military division of the French Atomic Energy Commission.**

(Commissariat à l'Energie Atomique – Direction des Applications Militaires)

- **Acquired MSS for Urban Emergency Response (Paris, other major cities).**
- **Develops a centralized operational system.**
- **Decided to fund the parallelization of the MSS code.**

MSS applications in PARIS

- *Release in the City Center : Châtelet – Les Halles*

- ***Courtesy of CEA-DAM***

Dr. Patrick ARMAND

MSS applications in PARIS

- *Release in the City Center : Place de la Concorde*

Elysée : French President’s Residence

US Embassy in Paris

- ***Courtesy of CEA-DAM***

Dr. Patrick ARMAND

Summary

- **Micro SWIFT/SPRAY (MSS) is operational in HPAC 5.0**
- **Current focus on validation**
  - JU 2003 and international studies
- **Comparisons with JU 2003 data indicate some successes, and some areas requiring more attention**
  - Correct modeling of advection (recirculation, channeling, vertical transport, etc.) in urban terrain may be more important than turbulent diffusion.
  - Results are highly dependent on MET input.
  - Collaboration between Röckle-based modelers is proceeding and demonstrating benefits.

Institute for Defense Analyses
4850 Mark Center Drive • Alexandria, Virginia 22311-1882

2007 CBIS Conference
Renaissance Austin Hotel
Austin, Texas
8-12 January 2007

Joint Effects Model Urban IPT

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Steve Warner
Jeffry Urban

January 11, 2007

Outline

1. JEM IPT Purpose and Goals

2. IDA's Role

3. Model Selection Criteria

4. Urban Models Under Consideration

5. Analysis Methodology

6. Results of Timing Runs

7. Summary/Way Ahead

JEM Urban IPT Purpose and Goals

- **Increment 2 (formerly Block 2) of the Joint Effects Model (JEM) has an urban transport and dispersion requirement**

- **Joint Science and Technology Office (JSTO) established the JEM Urban IPT to enable:**
  - A formal process for model selection, giving due consideration to the JEM Capability Production Document (formerly Operational Requirements Document)
  - Representation of the services in the selection process
  - Documentation of the process & results for eventual presentation to the Joint Requirements Office (JRO) and the JEM program office

IPT Members

Last	First	Title	Role	Email
Hamilton	Stephanie	CDR	JSTO Co-Chair	Stephanie.hamilton@dtra.mil
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Fill ins				
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Balcer	Joe	Mr.	USAF	Joseph.Balcer.ctr@langley.af.mil

IDA's Role

- **JSTO has requested IDA to facilitate the JEM Urban IPT**
  - IDA has no stake in the outcome of the selection process
  - Objectivity and freedom from bias
- **IDA has been tasked by JSTO to:**
  - Identify potential models
  - Screen models with respect to the selection criteria
  - Evaluate performance & effectiveness of models and identify potential JEM integration issues
  - Document process, results, and recommendations

Urban Model Selection Criteria

- **Models must be in accord with the JEM Capability Production Document (formerly JEM ORD)**
- **Models must meet requirements laid out in the JEM Block II Request for Information (RFI), conducted in 2004**
- **Model source code must be releasable to the U.S. Government**
  - No insurmountable proprietary issues
  - No insurmountable intellectual property issues
- **Other model requirements**
  - Acceptable hardware requirements
  - Acceptable data requirements
  - Acceptable preprocessing requirements
  - Acceptable level of expertise required to run models
- **Verification & Validation (V&V) history**
  - Models must have documented internal V&V
  - Models must have independent V&V (IV&V) involving comparisons to tracer releases at urban field trials
    - » Urban 2000 (Salt Lake City)
    - » Joint Urban 2003 (Oklahoma City)

Analysis Methodology

- **Review historical V&V documentation for models**
- **Perform model runs**
  - Using well-defined and open protocols, compare model predictions to Joint Urban 2003 tracer sampler data
    - » Time permitting, compare (re-compare) models to Urban 2000 field trials
  - Evaluate performance using established comparison metrics
    - » "Standard" T&D statistics
    - » Measure of Effectiveness (MOE)
    - » Rigorous hypothesis testing

Urban Models Under Consideration (1 of 2)

- **Urban Dispersion Model (UDM), DSTL, UK**
  - Gaussian Puff model that incorporates interactions with obstacles; interactions are functions of building density, height, and plume size
  - Presently in HPAC
- **Urban Windfield Module (UWM), Titan Corp.**
  - 3D wind field model; uses averaged NS equations and thermal/energy equations with distributed drag parameterization
  - Presently in HPAC
- **Micro-Swift-Spray, SAIC**
  - Micro-Swift: Empirical 3D wind field model that defines displacement, cavity, and wake “zones” around buildings
  - Micro-Spray: Lagrangian particle model that accounts for reflections from building surfaces
  - Presently in HPAC (beta testing)

Urban Models Under Consideration (2 of 2)

- **MESO/RUSTIC, ITT**
  - RUSTIC: 3D wind field model; uses averages NS equations and TKE dissipation method for turbulence
  - MESO: Lagrangian particle model that accounts for reflections from building surfaces
- **QUIC-URB/QUIC-PLUME, Los Alamos**
  - QUIC-URB: Empirical 3D wind field model (Röckle, 1990) to account for buildings
  - QUIC-PLUME: Lagrangian particle model that accounts for reflections from building surfaces

JEM Runtime Requirement

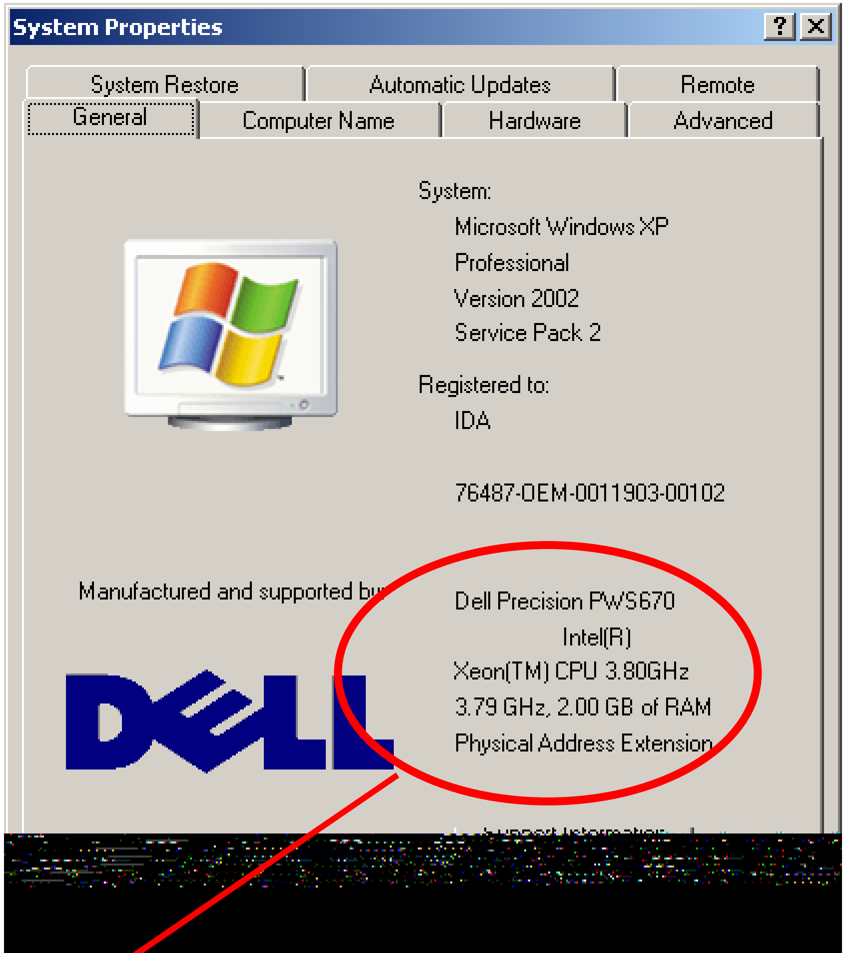
JEM Key Performance Parameter (KPP) 6a, *Joint Effects Model (JEM) Capability Production Document, Version 2.0, June 2006*

JEM, running without advanced features turned on, such as secondary evaporation, complex terrain, microscale meteorology, shall provide hazard prediction data and graphical display, for up to two known (location, agent, dissemination) source terms, within 10 minutes.

For the following analyses we will do single releases and compare runtimes against *5 minutes*

HPAC Urban Model Runtime Comparisons: *Computer Specs and General Info*

Computer



Single processor used during runs

General

- **Runs done using HPAC 4.04 SP3**
  - Includes vendor provided MicroSWIFT/MicroSpray (MSS)
- **Predictions for continuous releases of Joint Urban 2003 (JU2003) Field Trials**
  - 29 releases
    - » 30 minute releases
    - » 2 hour project time
  - Two Met Options
    - » Post Office rooftop PWIDS (PO7)
    - » Surface and upper air met from nearby airports (BAS)
  - SWIFT run with HPAC to generate mass-consistent winds

HPAC Urban Model Runtime Comparisons: *Urban Modes, Domains, and Spatial Resolution*

- **HPAC spatial domain: ~ 100 km x 100 km x 2.5 km**
- **Urban model configurations run within HPAC 4.04 SP3**
  - Urban Canopy parameterization = UC
  - Urban Dispersion Model (UDM) alone = DM
  - Urban Windfield Module (UWM) alone = WM
    - » UWM run in “high” and “low” horizontal spatial resolution
  - Urban Dispersion Model + Urban Windfield Module = DW
    - » UWM run in “high” and “low” horizontal spatial resolution
  - MicroSWIFT/MicroSPRAY = MSS
    - » MSS run in “high” and “low” horizontal spatial resolution
- **Horizontal domain, grid size, and number of particles for high and low resolution**

	"Low"			"High"		
	domain size	grid size	number of particles	domain size	grid size	number of particles
UWM	> 2500 m	> 50 m	NA	> 500 m	> 5m	NA
MSS	0.8 km x 0.8 km	5m	50000	1 km x 1 km	3m	100000

HPAC Urban Model Runtime Comparisons:
Oklahoma City, Baseline Weather

29 Oklahoma City Runs; Baseline Weather (BAS)				
Urban Mode / Resolution	**Average Run Time (min)**	**Median Run Time (min)**	**Min Run Time (min)**	**Max Run Time (min)**
Urban Canopy	2.1	2.1	1.9	2.5
UDM Alone	3.3	3.1	2.1	6.2
UWM Alone, low resolution	3.0	3.0	2.4	3.6
UWM Alone, high resolution	85.0	80.5	44.0	263.6
UWM + UDM, low resolution	3.8	3.7	2.7	5.2
UWM + UDM, high resolution	85.9	82.4	46.0	263.4
MSS, low resolution	28.7	26.5	21.3	55.1
MSS, high resolution	61.7	59.3	50.1	85.1

Satisfies JEM requirement
Does not satisfy JEM requirement, but is within 5 minutes
Does not satisfy JEM requirement

HPAC Urban Model Runtime Comparisons: *Oklahoma City, Post Office Weather*

29 Oklahoma City Runs; Post Office Weather (PO7)				
Urban Mode/Resolution	Average Run Time (min)	Median Run Time (min)	Min Run Time (min)	Max Run Time (min)
Urban Canopy	1.9	1.9	1.7	2.0
UDM Alone	2.9	2.8	1.9	5.7
UWM Alone, low resolution	3.2	3.2	2.8	3.7
UWM Alone, high resolution	86.3	91.1	50.3	146.5
UWM + UDM, low resolution	3.8	3.8	2.8	5.1
UWM + UDM, high resolution	86.8	92.2	51.0	145.8
MSS, low resolution	28.4	26.9	23.5	50.4
MSS, high resolution	61.8	60.6	54.6	76.1

- Satisfies JEM requirement
- Does not satisfy JEM requirement, but is within 5 minutes
- Does not satisfy JEM requirement

MESO RUSTIC Urban Model Runtime Comparisons: *Background*

- **Developer recommended MESO-RUSTIC configuration for *detailed scientific modeling*:**
  - RUSTIC grid resolution 3 - 5 meters in the urban center
  - 300,000 - 500,000 MESO particle tracers
- **MESO-RUSTIC configuration necessary to *run in several minutes (versus hours)*:**
  - 1.4 km x 1.4 km domain (Oklahoma City central business district only)
  - 25 to 50 m uniform horizontal grid resolution
  - Only two RUSTIC steady-state wind solutions per continuous release
  - 40,000 MESO particle tracers
  - 1 hour of simulated transport and dispersion
- **Timing runs were performed on a 3.40 GHz Pentium 4 with 1.0 GB RAM (single processor)**

MESO RUSTIC Urban Model Runtime Comparisons:
Timing results for 25 m and 50 m grid resolution; 40,000 particles

25 m RUSTIC grid resolution
40,000 MESO particles

IOP	Release	RUSTIC (min)	MESO (min)	Total (min)
2	3	10.13	1.50	11.63
4	2	9.07	1.07	10.13
4	3	7.33	0.83	8.17
7	1	13.12	2.05	15.17
9	3	8.23	3.00	11.23
Averages		9.58	1.69	11.27

50 m RUSTIC grid resolution
40,000 MESO particles

IOP	Release	RUSTIC (min)	MESO (min)	Total (min)
2	3	3.20	1.45	4.65
4	1	3.48	0.90	4.38
4	2	2.37	0.83	3.20
4	3	5.42	1.37	6.78
7	1	3.85	1.98	5.83
9	3	3.38	0.47	3.85
Averages		3.62	1.17	4.78

Satisfies JEM requirement
Does not satisfy JEM requirement, but is within 5 minutes
Does not satisfy JEM requirement

Times do not include the 1-3 minutes to generate the RUSTIC grid (could be pre-computed)

MESO RUSTIC Urban Model Runtime Comparisons:
Timing results for 25 m and 50 m grid resolution; 400,000 particles

25 m RUSTIC grid resolution
400,000 MESO particles

IOP	Release	RUSTIC (min)	MESO (min)	Total (min)
2	3	10.13	12.40	22.53
4	2	9.07	8.45	17.52
4	3	7.33	6.37	13.70
7	1	13.12	18.98	32.10
9	3	8.23	30.25	38.48
Averages		9.58	15.29	24.87

50 m RUSTIC grid resolution
400,000 MESO particles

IOP	Release	RUSTIC (min)	MESO (min)	Total (min)
2	3	3.20	14.07	17.27
4	1	3.48	8.53	12.02
4	2	2.37	9.27	11.63
4	3	5.42	12.97	18.38
7	1	3.85	20.73	24.58
9	3	3.38	4.08	7.47
Averages		3.62	11.61	15.23

Satisfies JEM requirement

Does not satisfy JEM requirement, but is within 5 minutes

Does not satisfy JEM requirement

RUSTIC only Urban Model Runtime Results:
Larger grid size & higher resolution grids

A) 8.0 km x 8.0 km grid – <u>single</u> steady-state wind solution

IOP	Release	RUSTIC Runtime (min)
2	3	174.35
4	1	372.63
4	2	240.82
4	3	159.67
7	1	150.90
9	3	372.63

B) 1.4 km x 1.4 km grid at higher resolutions – <u>single</u> steady-state wind solution (times in minutes)

		RUSTIC Runtimes (min)		
IOP	**Release**	**20 m resolution**	**14 m resolution**	**7 m resolution**
2	3	12.47	50.33	286.90
7	1	34.38	134.87	487.23
9	3	22.77	87.60	381.05

Does not satisfy JEM requirement

QUIC-URB QUIC-PLUME Initial Runtime Analyses: *Background*

- **Developer recommended QUIC-URB, QUIC-PLUME configuration for *detailed scientific modeling*:**
  - QUIC-URB horizontal grid resolution of ~ 5 meters
  - ~ 400,000 QUIC-PLUME particle tracers
- **QUIC-URB, QUIC-PLUME configuration necessary to *run in several minutes (versus ~ 1 hour)*:**
  - 1.4 km x 1.4 km domain (Oklahoma City central business district only)
  - 10 m horizontal grid resolution (6 m vertical resolution)
  - 8 steady-state wind solutions per continuous release (15 minute averaged winds)
  - < ~ 50,000 QUIC-PLUME particle tracers
  - 2 hours of simulated transport and dispersion
- **Computer**
  - 2.33 GHz MacBook Pro (running Windows XP) with 2.0 GB RAM

QUIC-URB QUIC-PLUME Initial Runtime Analyses:
Example timing results for "low" (10 m) resolution

Post Office PWIDS weather data
15 minute averages, 8 updates
2 hours of simulation time

IOP 1, Continuous release: 10 m QUIC-URB grid resolution

# of QUIC-PLUME Particles	QUIC URB (min)	QUIC PLUME (min)	Total (min)
10000	3.08	2.19	5.27
50000	3.08	9.19	12.27
100000	3.08	14.88	17.96
200000	3.08	33.73	36.81
400000	3.08	61.85	64.93

Satisfies JEM requirement
Does not satisfy JEM requirement, but is within 5 minutes
Does not satisfy JEM requirement

QUIC-URB QUIC-PLUME Initial Runtime Analyses:
Example timing results for “high” (5 m) resolution

Post Office PWIDS weather data
15 minute averages, 8 updates
2 hours of simulation time

IOP 1, Continuous release: 5 m QUIC-URB grid resolution

# of QUIC-PLUME Particles	QUIC URB (min)	QUIC PLUME (min)	Total (min)
10000	15.56	4.55	20.11
50000	15.56	7.79	23.35
100000	15.56	17.20	32.76
200000	15.56	23.75	39.31
400000	15.56	47.86	63.42

Does not satisfy JEM requirement

Beyond the 10 Minute Requirement

- **Many (non-operational, non-combat) release scenarios exist where time is *not critical***
- **For such scenarios it may make sense to have a model that can give "high fidelity" results in runtimes greater than 5 minutes, but less than say, one hour**
- ***JEM 10 minute requirement alone may not exclude models from eventual/potential JEM consideration***

Summary / Way Ahead

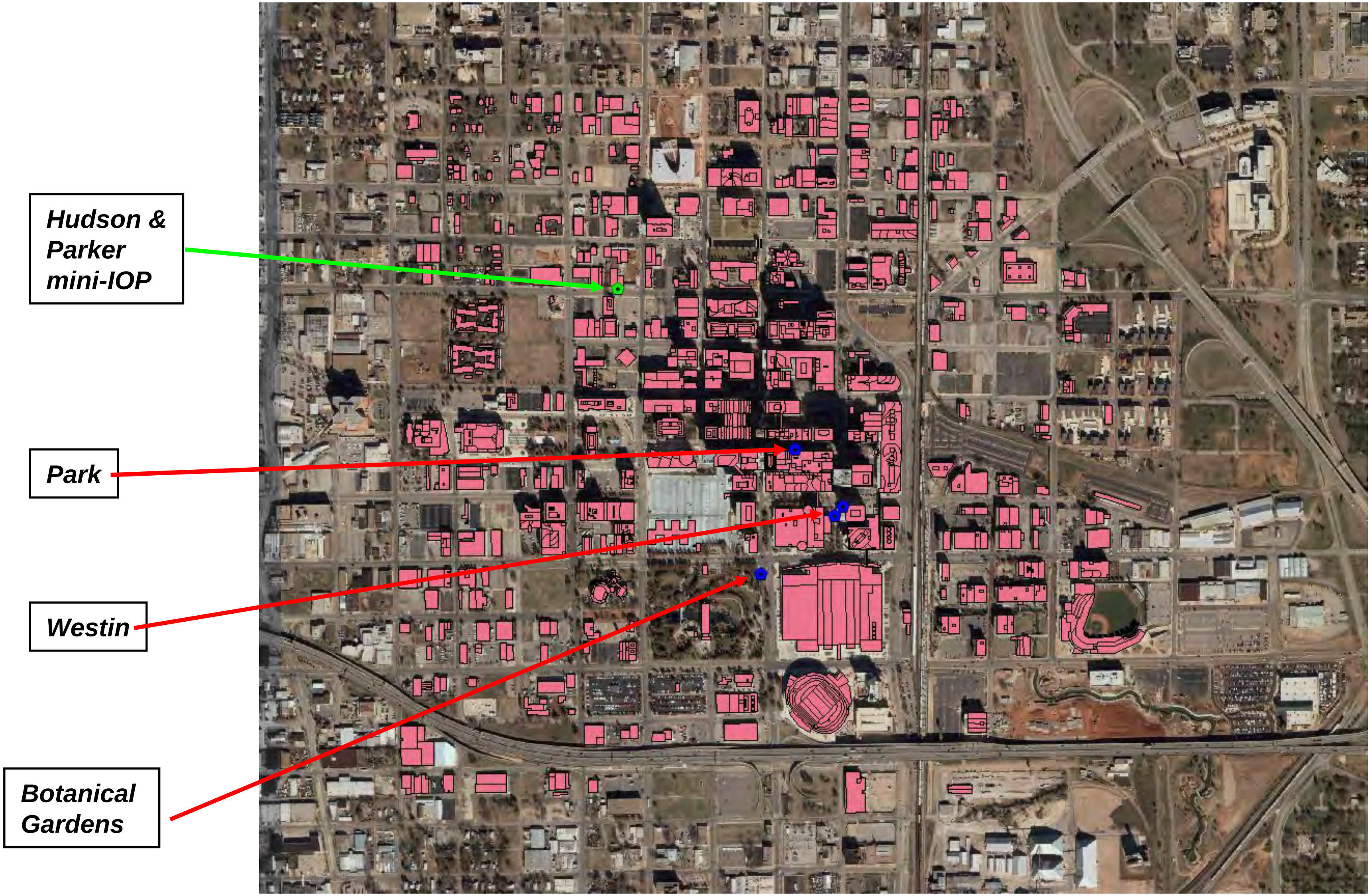
- **Timing Results**
  - HPAC models
    - » UC, UDM, UWM (low resolution) and UDM/UWM (low resolution) satisfy the JEM 10 minute requirement
    - » MSS does not satisfy JEM 10 minute requirement even with low resolution
    - » UWM with high resolution (singly or with UDM) does not satisfy JEM 10 minute requirement
  - MESO/RUSTIC
    - » Can satisfy the JEM 10 minute requirement, but only with low resolution (10 times coarser than recommended) and small numbers of tracer particles (10 times fewer than recommended)
    - » Quality of low resolution/low particle number predictions is still under investigation
  - QUIC-URB/QUIC-PLUME
    - » Can satisfy the JEM 10 minute requirement, but only with low resolution (2 times coarser than recommended) and small numbers of tracer particles (8 times fewer than recommended)
    - » Quality of low resolution/low particle number predictions is still under investigation

- **To Do**
  - Near term: Full report to JEM Urban IPT (February '07)
  - Far term: Complete detailed intercomparison between all models (~ June '07, currently underway)

Go EAGLES!

BACKUPS

JU2003 Downtown - Releases



HPAC Urban Model Runtime Comparisons: *Summary*

- **Based on these Oklahoma City runs, the following models and configurations *satisfy the JEM runtime requirement***
  – Urban canopy model
  – UDM
  – UWM with low resolution
  – UDM together with low resolution UWM
- **Based on these Oklahoma City runs, the following models and configurations *do not satisfy the JEM runtime requirement***
  – UWM with high resolution
  – UDM together with high resolution UWM
  – MSS with both low and high resolutions

MESO RUSTIC Urban Model Runtime Comparisons: *Summary*

- **MESO/RUSTIC can satisfy the JEM 10 minute requirement consistently only when run with:**
  - Low grid resolution (50 m - ***a factor of 10 coarser than recommended***)
  - Particle numbers roughly ***a factor of 10 fewer than recommended***
  - Few steady-state wind updates
- **RUSTIC is the time bottleneck – can take *hours* for high resolution (<10 m) grids or larger (several km) domains**
- **MESO itself can run on the order of 10 minutes for 1 hour of simulated time using the recommended number of particle tracers on a coarse RUSTIC grid (> 25 m)**
  - Can run on the order of minutes using a reduced number of tracers
  - Grid resolution does not seem to be the limiting time factor for MESO
- **MESO-RUSTIC results have not yet been validated at low resolution**

QUIC-URB QUIC-PLUME Initial Runtime Analyses: *Summary*

- **QUIC-URB and QUIC-PLUME can satisfy the JEM runtime only when run with**
  - Low grid resolution (10 m - ***a factor of 2 coarser than recommended***)
  - Low number of tracer particles (< ~ 50, 000 - ***a factor of 8 fewer than recommended***)
- **For low grid resolution, the QUIC-PLUME (particle evolver) runtime dominates the total runtime**
  - QUIC-PLUME runtime goes roughly linearly with increasing particle number for small particle numbers (~ 10^4), then sub-linearly for high number of particles (~ 10^5)
- **For high resolution, the runtime for QUIC-URB alone does not satisfy the JEM 10 minute requirement**

2007 CBIS

Atmospheric Chemistry of Toxic Industrial Chemicals

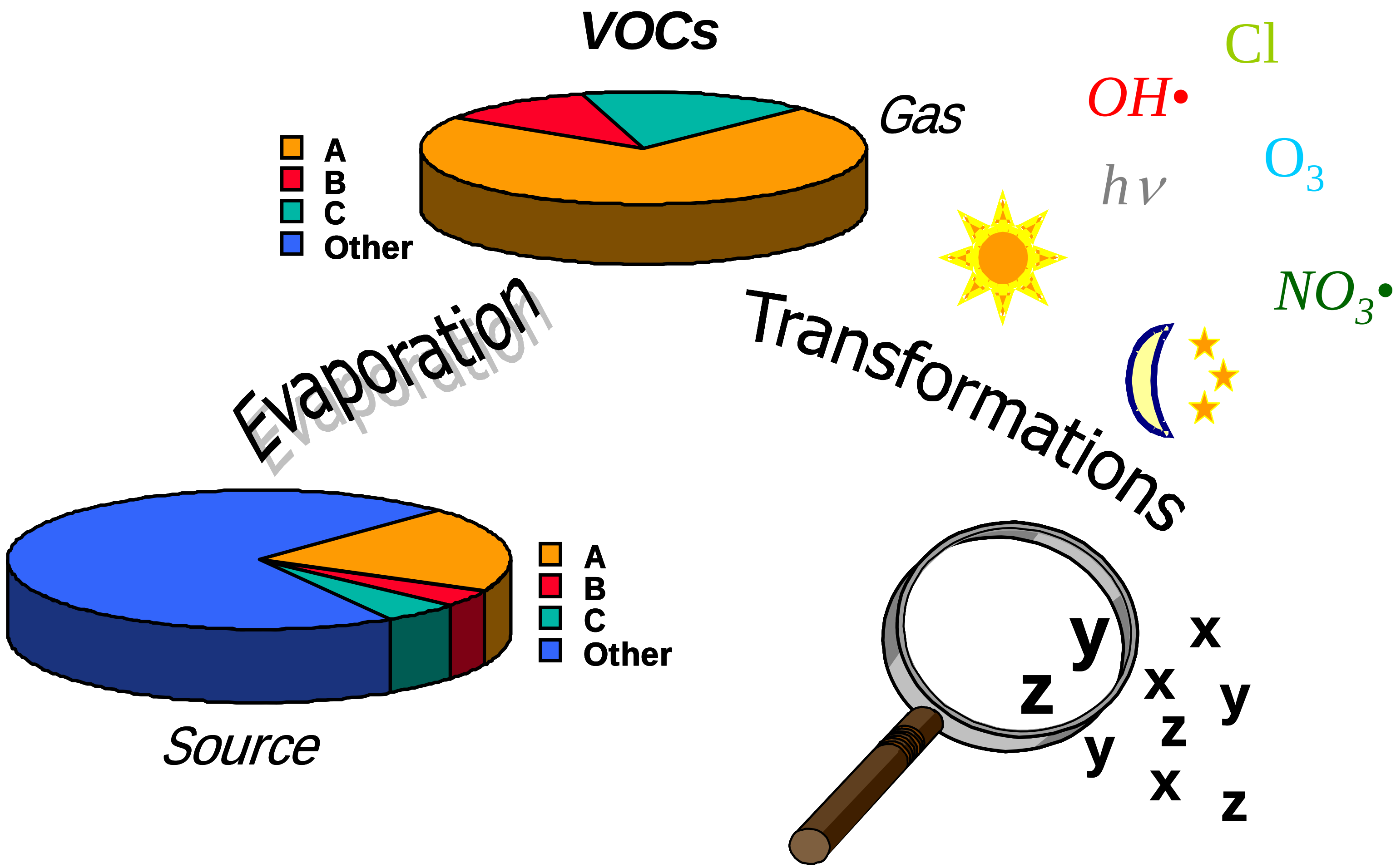
11 Jan 2007

Michael V. Henley, Airbase Technologies Division,
Materials & Manufacturing Directorate, Tyndall AFB, Florida

Overview

- Introduction to Atmospheric Chemistry
- Importance to Dispersion Modeling
- TIC Kinetics
- Past, Present, Future

Atmospheric Chemistry of Volatile Organic Compounds



Tropospheric Oxidant Formation

Ozone

$$NO_2 + h\nu \longrightarrow NO + O(^3P)$$
$$O(^3P) + O_2 \xrightarrow{M} O_3$$

OH Radical

$$O_3 + h\nu \longrightarrow O(^1D) + O_2$$
$$O(^1D) + H_2O \longrightarrow 2\ OH\bullet$$

NO_3 Radical

$$NO_2 + O_3 \longrightarrow NO_3\bullet + O_2$$
$$NO_2 + NO_3\bullet \rightleftarrows N_2O_5$$

Tropospheric Transformations

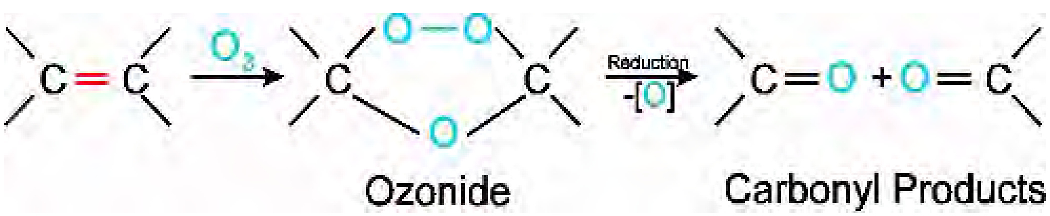
Photolysis

$$NO_2 + h\nu \xrightarrow{\lambda < 420\text{nm}} NO + O(^3P)$$

$$O_3 + h\nu \xrightarrow{\lambda < 325\text{nm}} O(^1D) + O_2$$

$$Cl_2 + h\nu \longrightarrow 2\ Cl$$

Ozonolysis

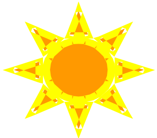


Typical $[O_3]$ = 2.5×10^{12} molecules/cm^3
100 ppb @STP

Important Radical Reactions

$$RH + OH\cdot \longrightarrow R\cdot + H_2O$$
$$R\cdot + O_2 \longrightarrow RO_2$$
$$RO_2 + NO \longrightarrow NO_2 + RO$$
$$NO_2 + h\nu \longrightarrow NO + O$$
$$O + O_2 + M \longrightarrow O_3 + M$$

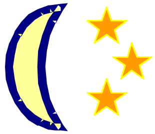
$$RH + OH\cdot + 2O_2 \longrightarrow RO + H_2O + O_3$$



Typical [OH] =
1 x 10^6 molecules/cm^3
3.72 x 10^{-2} ppt @STP

$$RH + NO_3\cdot \longrightarrow R\cdot + HNO_3$$
$$R\cdot + O_2 \longrightarrow RO_2$$
$$RO_2 + NO_3\cdot \longrightarrow NO_2 + RO + O_2$$
$$NO_2 + O_3 \longrightarrow NO_3\cdot + O_2$$

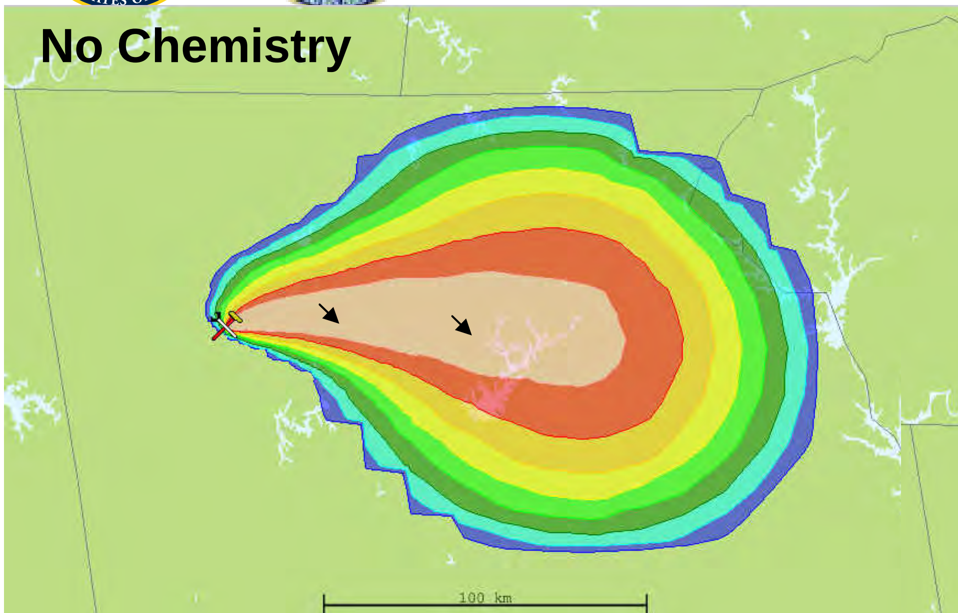
$$RH + NO_3\cdot + O_3 \longrightarrow RO + HNO_3 + O_2$$



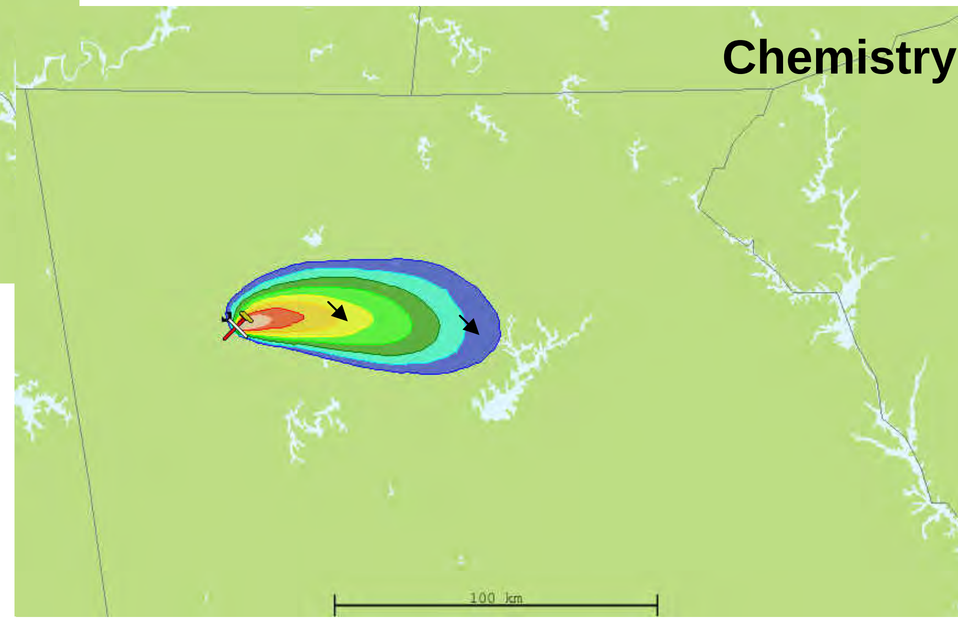
Typical [NO_3] =
2.5 x 10^8
molecules/cm^3
9.3 ppt @STP

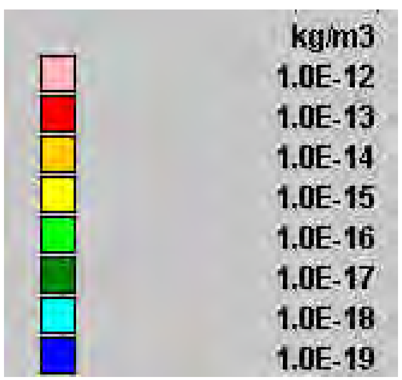
Example: Methylpropene

8 hr continuous release starting at 8 am local time



3 PM Local Time





Slide provided by ENSCO, Inc.

Reaction Kinetics

- Photolysis:

$$\text{TIC} \xrightarrow{h\nu} \text{Products}$$

$$-d[\text{TIC}]/dt = k_p[\text{TIC}],\ k_p \text{ in sec}^{-1}$$

- Bimolecular reaction:

$$\text{TIC} + \text{OH}/\text{NO}_3/\text{O}_3/\text{Cl} \longrightarrow \text{Products}$$

$$-d[\text{TIC}]/dt = k_{OH}\ [\text{TIC}][\text{OH}],$$
$$k_{OH} \text{ in cm}^3 \text{ molecules}^{-1} \text{ sec}^{-1}$$

Example of TIC Kinetic Data

Name	CAS #	Reaction with OH Radicals	Reaction with Ozone	Reaction with NO3 Radicals
		Reaction Rate, cm3 mol-1 s-1	Reaction Rate, cm3 mol-1 s-1	Reaction Rate, cm3 mol-1 s-1
1,1-dichloroethylene	75-35-4	8.1 x 10-12	3.7 x 10-21	1.23 x 10-15
1,1-difluoroethylene	75-38-7	4.0 x 10-12	1.4 x 10-19	
2-methylpropene	115-11-7	5.14 x 10-11	1.13 x 10-17	3.32 x 10-13
acetaldehyde	75-07-0	1.5 x 10-11	<6 x 10-21	2.7 x 10-15
acetylene	74-86-2	7.80 x 10-13	1 x 10-20	<1 x 10-16
carbon monoxide	630-08-0	2.08 x 10-13		<4 x 10-19
chloroethylene	75-01-4	2.36 x 10-12		2.93 x 10-16
chloromethane	74-87-3	4.2 x 10-14		
diethyl ether	60-29-7	1.3 x 10-11		
dimethyl ether	115-10-6	2.8 x 10-12		<3 x 10-15
dimethyl sulphide	75-18-3	4.80 x 10-12	<1.0 x 10-18	1.1 x 10-12
dimethylamine	124-40-3	6.54 x 10-11	2.61 x 10-18	
ethanethiol	75-08-1	4.64 x 10-11		9.87 x 10-13
ethyl vinyl ether	109-92-2	4.04 x 10-11	1.54 x 10-16	
ethylamine	75-04-7	2.77 x 10-11	2.76 x 10-20	
ethylene oxide	75-21-8	8 x 10-14		
hydrogen cyanide	74-90-8	3.0 x 10-14		
hydrogen sulfide	7783-06-4	4.7 x 10-12		<1 x 10-15
isoprene	78-79-5	1.0 x 10-10	1.27 x 10-17	7.0 x 10-13

Atmospheric Lifetime

- Bimolecular reaction:

$$TIC + OH/NO_3/O_3/Cl \longrightarrow Products$$

$$-d[TIC]/dt = k_{OH} [TIC][OH],$$

k_{OH} in cm^3 $molecules^{-1}$ sec^{-1}

- Lifetime (τ) Calculation
  - Time for the TIC to decrease to 1/e of its initial value
  - Oxidant [OH] assumed to be constant @ 1×10^6 molecules cm^{-3}
  - $\tau = 1/(k_{OH} * [OH])$
  - Example where kOH = 10×10^{-12} cm^3 $molecules^{-1}$ sec^{-1}

    $\tau = 1/(10 \times 10^{-12} * [1 \times 10^6])$

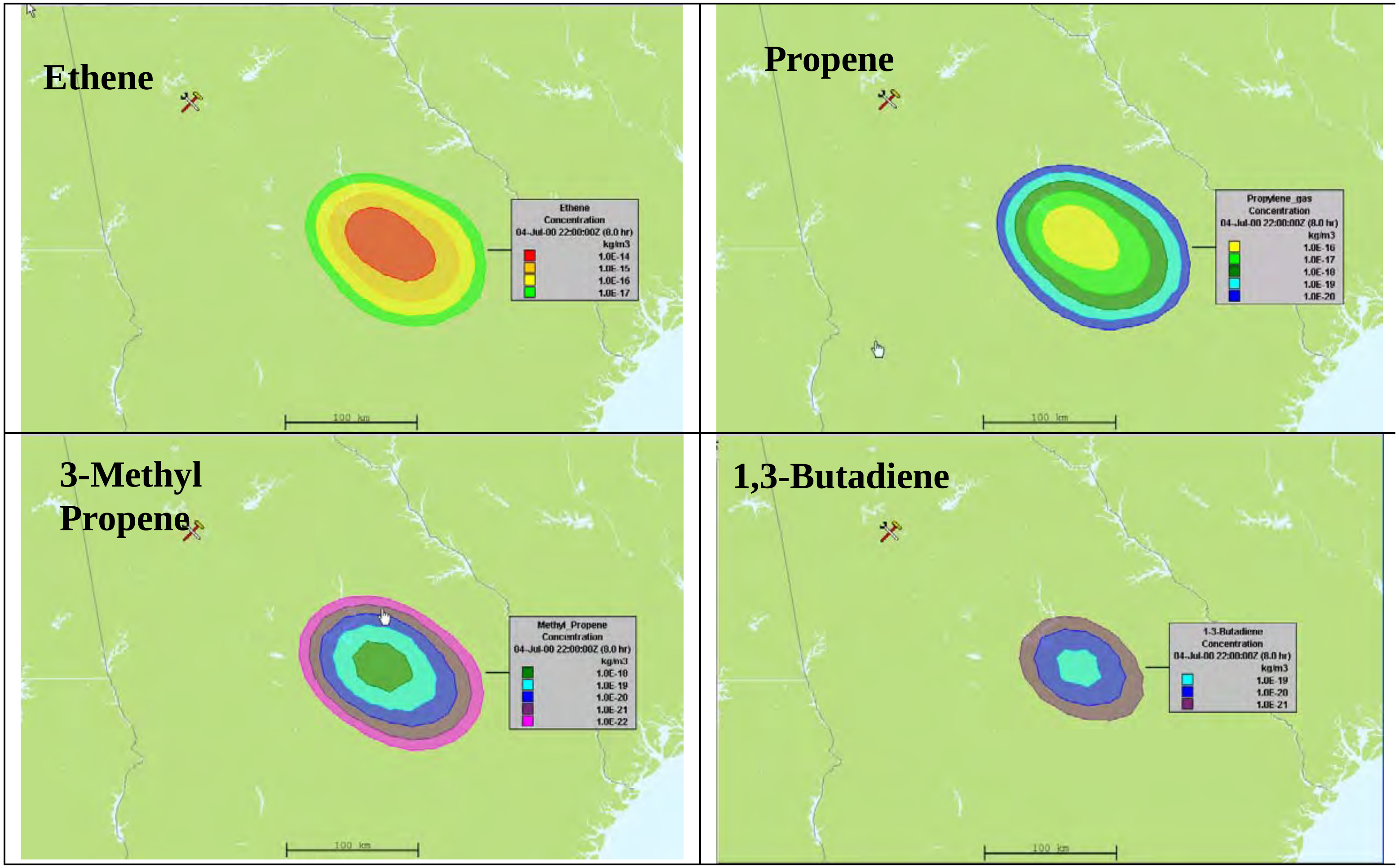
    $\tau = 1 \times 10^5$ sec ÷ 86,400 sec/day ~ 1.2 days

Estimated Atmospheric Lifetimes

Organic	OH [1×10^6 cm^{-3}], 0.038ppt	O_3 [2.5×10^{12} cm^{-3}], 100ppb	NO_3 [1.3×10^9 cm^{-3}], 50ppt	Cl [1×10^4 cm^{-3}], 0.00038ppt
n-Butane	5 days	≥ 1300 yr	205 days	5 days
trans-2-Butene	4.3 hours	36 min	35 min	~4 days
Acetylene	14 days	≥ 400 days	≥ 188 days	~22 days
Toluene	2 days	≥ 400 days	138 days	20 days
Formaldehyde	1.2 days	≥ 463 days	16 days	16 days
Hydrogen sulfide	2.5 days	-	≥ 213 days	-

Table derived from Finlayson-Pitts & Pitts, 2000

Calculated Plume is TIC Dependent



Slide provided by ENSCO, Inc.

Past, Present & Future

- Atmospheric chemistry plays significant role in dispersion of many TICs
- Kinetic data necessary to model reactivity
- Degrade algorithm developed for SCIPUFF
- Model optimization and sensitivity studies underway
- Chamber experiments for degrade algorithm validation being designed
- Heterogeneous aerosol interactions need addressing

Acknowledgements

In-house team:

Sheryl Calidonna (ARA)

Jean Renard (Retired)

Patrick Laine (ARA)

ENSCO, Inc. team:

Jeff Piotrowski

Doug Burns

Kia Taveras

Date Chynwat

Floyd Wiseman

Side-By-Side Comparison of Mobile Force Modeling Methods for Operational Effects and Virtual Prototyping

Defense Threat Reduction Agency (DTRA) Joint Science and Technology Office – Chemical and Biological Defense (JSTO-CBD) program.

Camillus W.D. "Dave" Hoffman, PI
Scott Cahoon
Sonia von der Lippe
111700 January 2007

The Mobile Forces Assessment Objective

To perform a comparative assessment of the available field of models and simulations (M&S) for their analytical and modeling potential with regard to

- Modeling chemical and biological (CB) effects on mobile forces,
- Exposing CB impacts on operations, and
- Performing analyses of alternatives for determining optimum courses of action under various adverse CBRN conditions.

Background

- The assessment was fostered with a view to identifying analytical M&S tools that will be recommended for membership among the Joint Operational Effects Federation (JOEF) CBRN M&S tool suite.

- The intended users of JOEF are Warfighters at the three major levels of warfare
  - Strategic
  - Operational
  - Tactical

Assessment philosophy

- Users define application requirements
- Application requirements drive tool capabilities requirements
- Everything else is secondary

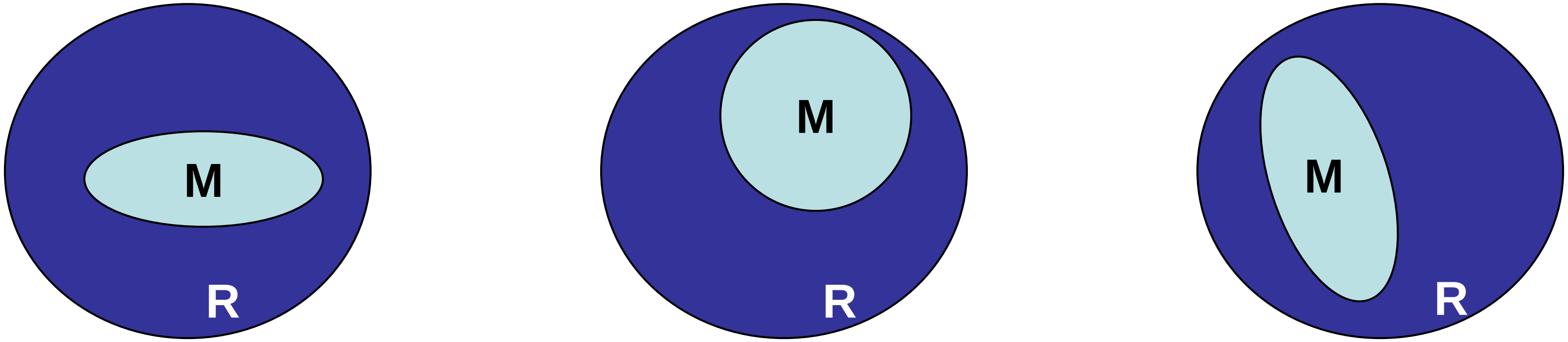
So

- Who are the users?
- What are their application requirements?
- What are their tool requirements?

Assumptions

- All models are wrong (imperfect); some are useful
  - No single M&S tool will adequately answer all questions
  - The task or the analytical questions drive the choice of M&S tool

<u>The Case of Three Rotary Wing Flight Models</u>



Practical Example

- COCOMs worry about TPFFDL flow
  - They need M&S that help them optimize throughput through available nodes (such as a port) and the impact and best alternative if a node is lost to a CBRN attack.
- Port commanders worry about port operations.
  - Port commanders require M&S that will help them optimize port operations in the event of a CBRN attack.

The optimum types of M&S for each of these applications would probably be different

Assumptions (continued)

- The Army and JFCOM will have the preponderance of potential mobile forces M&S tools
- “Analytical potential” requires statistical reliability
- The three major levels of warfare will have different questions and will probably require different tools

Approach

Task	Products		
M&S Survey →	Users Applications →	CBRN Applications (Empirical & Inferred) →	Capabilities Capability Requirements
User Application Survey →	M&S Applications →	CBRN Applications (Empirical & Inferred) →	Capabilities Capability Requirements
Mobile Forces Criteria Definition →	M&S Typing Binning Criteria Binning Prioritization →	Cross-walk M&S Types with Priorities →	Identify Mobile Forces M&S Solutions

Approach

- Mobile Forces M&S survey
- CBRN application survey
- Mobile forces criteria definition

Mobile Forces M&S Survey

- What CB M&S currently exist or are planned for development?
- What are their use histories?
- Who are the M&S proponents/owners and their clients?
- What services and what agencies within those services use these M&S
- What are their resolutions and fidelities?
- What CB modeling currently exists within them?
- What CB applications have been conducted or are projected to be conducted with them?
- What CB analyses are envisioned which cannot be conducted for a want of CB modeling?

Mobile Forces M&S Survey

- Centers of excellence (M&S and CBRN)
- Web
- Symposia (ITSEC, etc)

Approach

- Mobile Forces M&S survey
- <u>CBRN application survey</u>
- Mobile forces criteria definition

CBRN Application Survey

Start with the three levels of warfare

- What is the scope of the M&S that are currently used?
- Search areas: Army centers of excellence
  - Battalion/brigade (tactical?) TRAC-WSMR
  - Division/corps (operational?) TRAC-FLVN
  - Army/theater (strategic?) CAA
  - JFCOM
  - OSD support?

CBRN Application Survey
(Continued)

- What are their issues and how are they examined? Then
  - Derive notional questions on how a CBRN attack might affect those results?
  - Look for similarities and differences
  - Derive CBRN related functionality requirements that we can use to define classes of applications and classes of M&S tools to support them
- Caveat: No intent to suggest that the assessment will identify all possible application questions.

Approach

- Mobile Forces M&S survey
- CBRN application survey
- <u>Mobile forces criteria definition</u>

Mobile Forces Criteria Definition

- Classify applications by M&S resolution/fidelity types

- Cross-walk M&S with application survey

- Develop and prioritize binning criteria

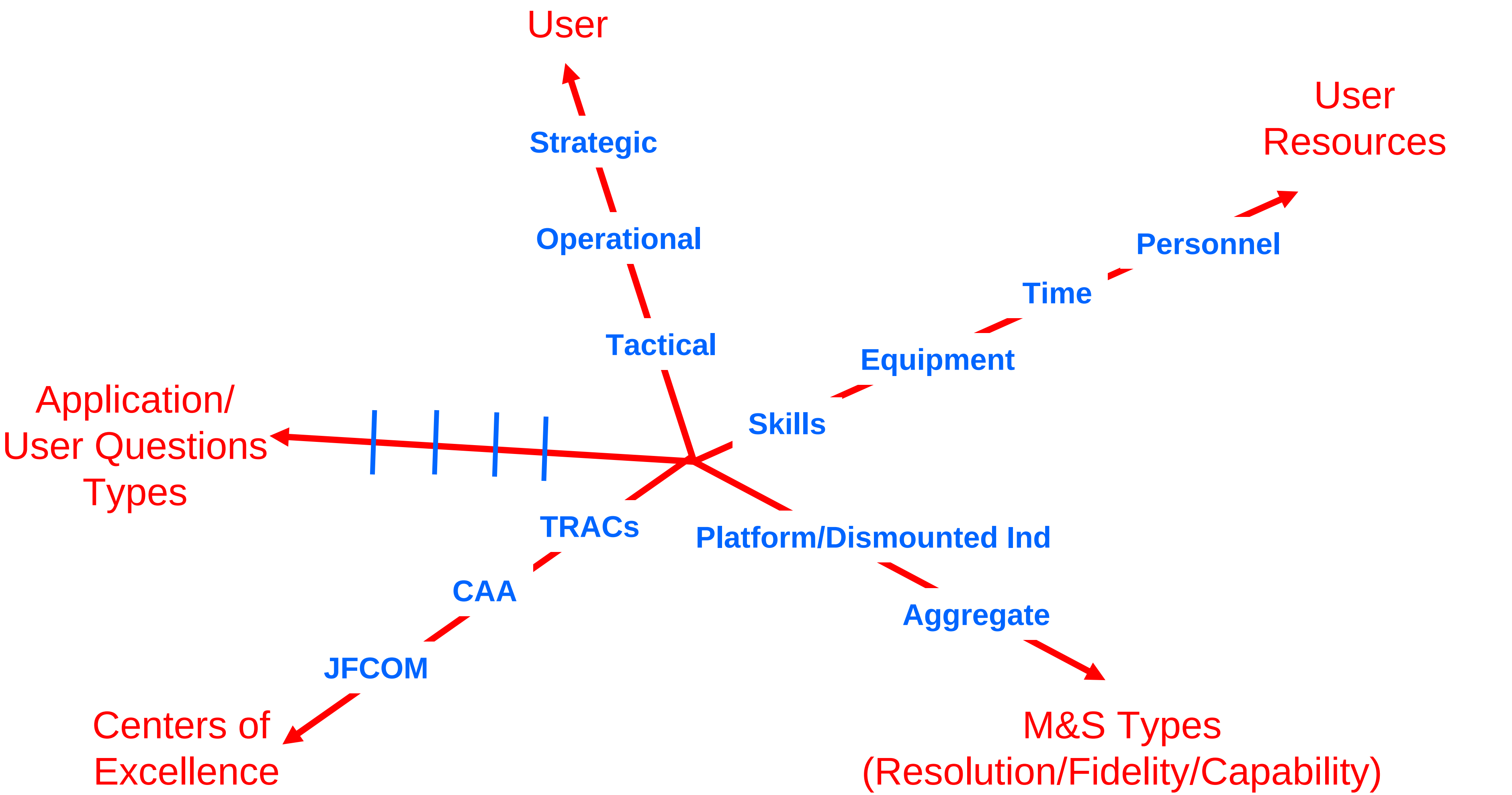
- Assess M&S within M&S resolution/fidelity types by binning criteria

Initial Binning Criteria

- CBRN application history
- Resolution (individual vs corps)
- Fidelity (movement, sight, respiratory, etc.)
- Statistical reliability
- Ease of modeling (for rapid prototyping)
- Joint (Army & USMC)
- Resource requirements (adequate and skilled staffing)

Summary

Perceived Survey & Assessment Space



Notional Result

Binning Priority	Tactical		Operational		Strategic	
	$M\&S_a$	$M\&S_b$	$M\&S_c$	$M\&S_d$	$M\&S_e$	$M\&S_f$
Statistical Reliability	x	x	x	x	x	x
Resource Rqts	x	x	x		x	x
Resolution		x	x		x	
Fidelity		x	x	x	x	
Joint	x			x	x	
CBRN History				x		x
Ease of modeling	x		x	x		

Emerging Results

- There are legacy mobile forces M&S resident at Army and USMC centers of excellence that meet most critical binning criteria, but…

- The use of M&S by Warfighter CBRN staffs is revolutionary (not evolutionary) with an inherent problem
  - CBRN staff sections are often one or two deep
  - Most often they do not have requisite technical skills.
  - Categorically, they would never have enough time to prepare an M&S and analyze the output data.
- The above begs solutions such as
  - Simplification of M&S use.
  - Incorporation of existing centers of excellence or creation of CBRN center(s) of excellence resourced to support the Warfighter (similar to the DTRA HPAC paradigm)

Emerging Results
(Continued)

- There is little tradition of CBRN M&S application analyses and resulting CBRN related modeling

- The above suggests that CBRN M&S capabilities need to be resident in current Warfighter mobile forces M&S analysis tools
  - The history of CBRN analyses probably would not justify the overhead of unique mobile forces M&S for CBRN analysis

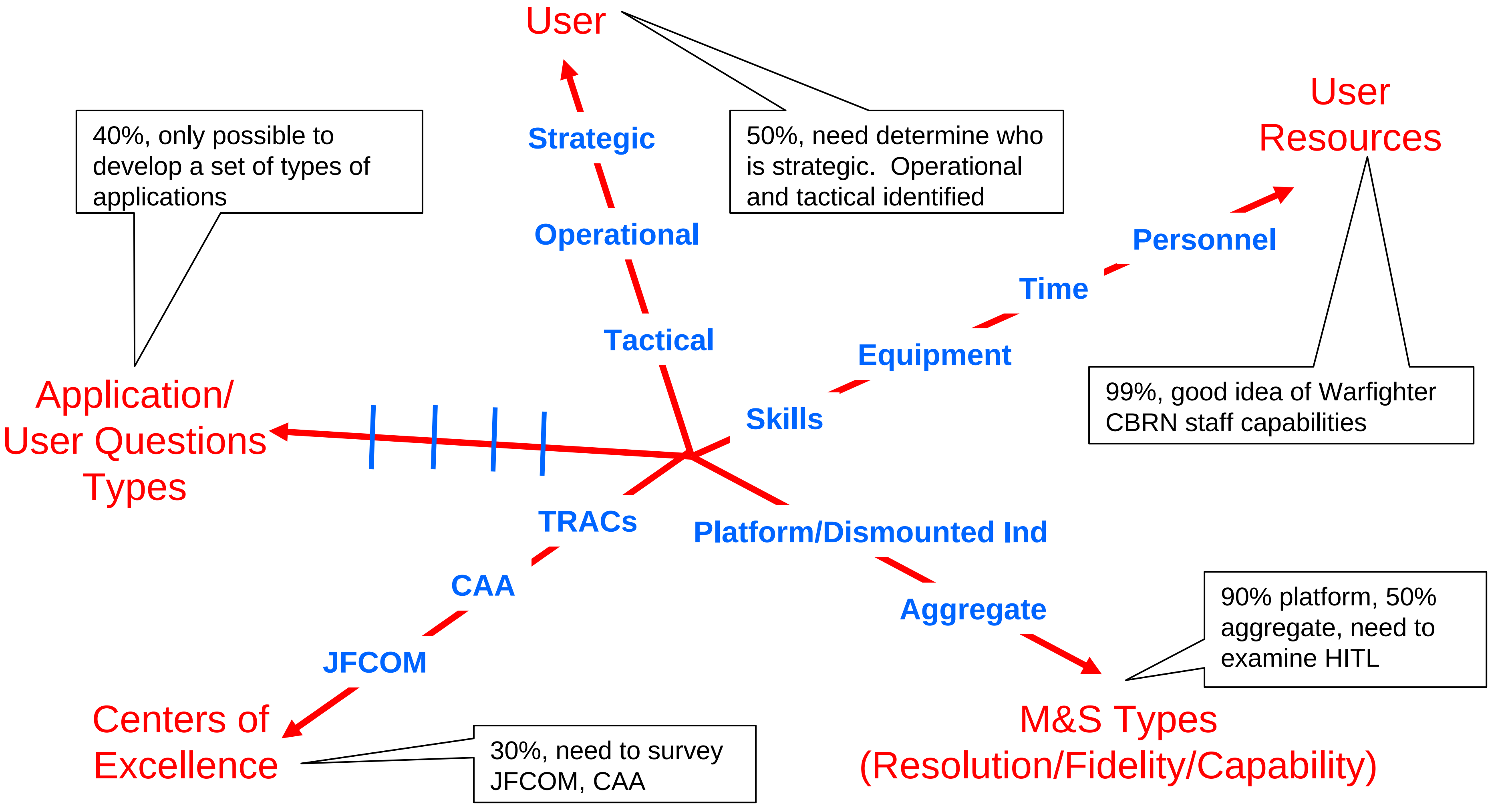
Emerging Results
(Continued)

- In process of surveying human in the loop (HITL) M&S (Janus, OTB, etc) for analysis
  - How are users of HITL conducting analysis and is it applicable to JOEF?
  - Known users,
    - TRAC-WSMR
    - Ft Knox
    - JFCOM?
- Intuitively, statistical reliability an issue
- HITL requires far greater resources for M&S execution (terminals, personnel, time, etc) and would appear less of a candidate for use at Warfighter HQs (COCOMs, service component commands, corps, etc)

Emerging Candidates

- Platform/Individual: COMBAT^{XXI}
  - Statistical reliability
  - Joint Army-USMC development
  - Tool of choice for their analysis of alternatives
- Aggregate: Multiple possibilities
  - AWARS (Army)
  - JICM (COCOM tool of choice for TPFFDL analysis)

Status


User
50%, need determine who is strategic. Operational and tactical identified
Strategic
Operational
Tactical
User Resources
Personnel
Time
Equipment
Skills
99%, good idea of Warfighter CBRN staff capabilities
40%, only possible to develop a set of types of applications
Application/ User Questions Types
TRACs
CAA
JFCOM
Centers of Excellence
30%, need to survey JFCOM, CAA
Platform/Dismounted Ind
Aggregate
90% platform, 50% aggregate, need to examine HITL
M&S Types (Resolution/Fidelity/Capability)

Questions and

Suggestions

(collecting cards)

Joint Operational Effects Federation (JOEF) Briefing to CBIS

January 2007

Ms. Kathy Houshmand
JOEF Deputy Acquisition Program Manager
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Background

PROGRAM SUMMARY:	**Enables Warfighter and planners to assess CBRN effects on operations, personnel, and equipment and to recommend COAs to minimize or eliminate threat.**
HOST C4I SYSTEMS:	**GCCS-J, GCCS-M, GCCS-A, GCCS-AF, GCCS-K, JC2, TBMCS, C2PC**
USERS:	**Strategic and Operational Planners, Joint Commanders & Staff, NBC Command Center**

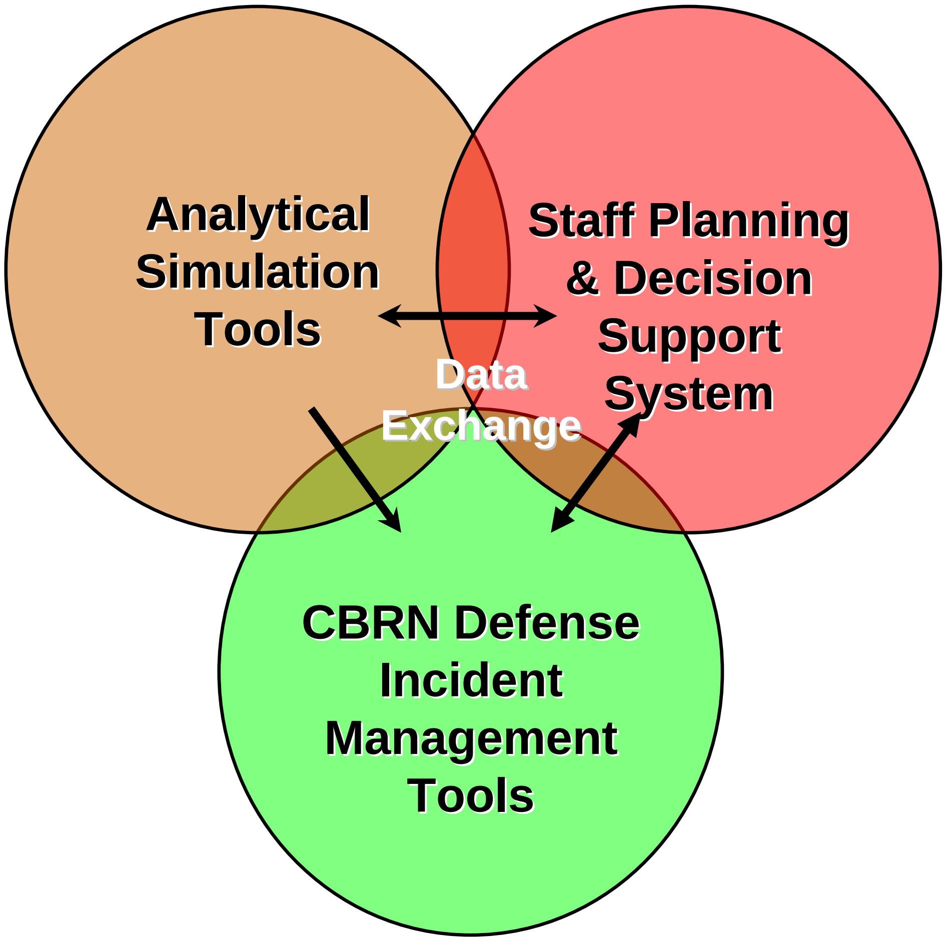
JOEF Increments Summary

- **Increment 1: Initial Operational Capability, June 2008**
  - **APODs, SPODs, TacAir, Medical, Mobile Forces,**
  - **Deliberate Planning (Operational, Strategic)**
  - **Crisis Planning (Operational)**
  - **Resides on C4I Systems**

- **Increment 2: *TBD***
  - **Consequence Management (Military)**
  - **Crisis Planning (Tactical)**
  - **Standalone**

- **Increment 3: *TBD***
  - **Consequence Management (Coalition)**

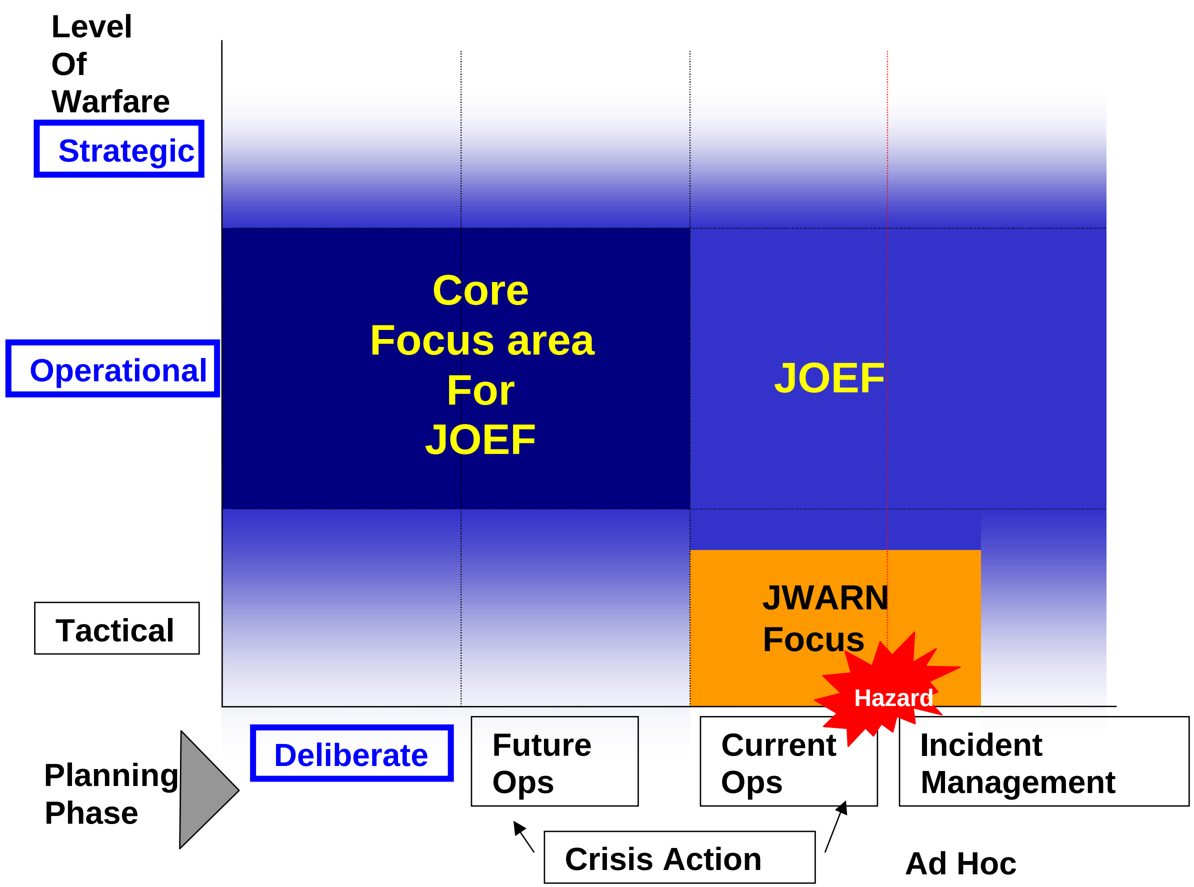
JOEF Overview



JOEF Requirements include:

– Deliberate planning tool
– Operational Effects Prediction Tool
– Access Data in Near Real Time
– COE and NCES Compliance
– Interoperability with C4I and M&S systems
– Net Ready – A Joint integrated architecture

JOEF User and Temporal Context



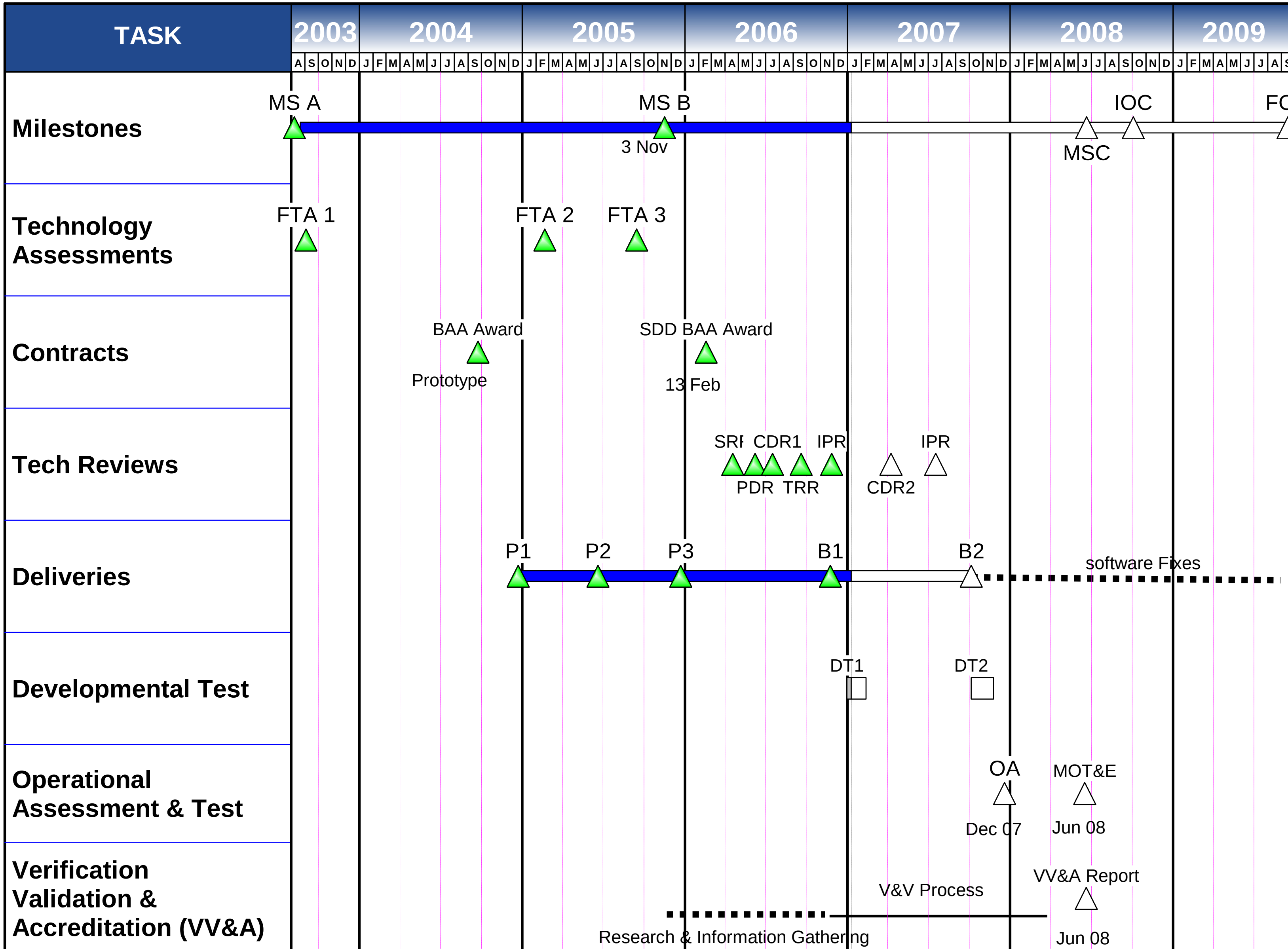
Program Acquisition Approach

- Utilize Broad Agency Announcement (BAA) for Software Development
  – Contract awarded in February 2006 to Cubic
- Spiral Software Development
  – Increment 1: 3 Prototypes; 2 Formal Builds
  – Science & Technology Transition
    - Insertion: Prototypes (3); Build 1 and 2
  – Provide Interim capabilities to Warfighters
    - Signal Fire
- Keep working with Warfighters to refine requirements and enhance the end product

Software Development Approach

- Increment 1: 3 Prototypes; 2 Formal Builds
  - Build 1: Nov 06
    - KPP 1: Deliberate and Crisis Planning Tool
    - KPP 2: Operational Effects Prediction Tool
  - Build 2: Sep 07
    - KPP 3: Access Data in Near Real Time
    - KPP 4: Interoperability: JEM; GCCS-M/AF/A/J; JC2
    - KPP 5: Net-Ready

JOEF Schedule – Increment I



JOEF Increment I Major Activities

Software Development

Design/Develop JOEF Build1	Design Build 2	Develop JOEF Build 2

JOEF Contract Awarded Feb 06

Deliver JOEF Interim Signal Fire Version Jan 07

Deliver JOEF Inc. I Version Sept 07

Testing and Fielding

Government Testing	Fielding of JOEF Increment I

Govt Test Dec 07

IOC 4 Qtr FY08

FOC 4 Qtr FY09

Increment I:

(Before the CBRN Event)

Deliberate Planning
Crisis Planning

Support to CBRN Planning

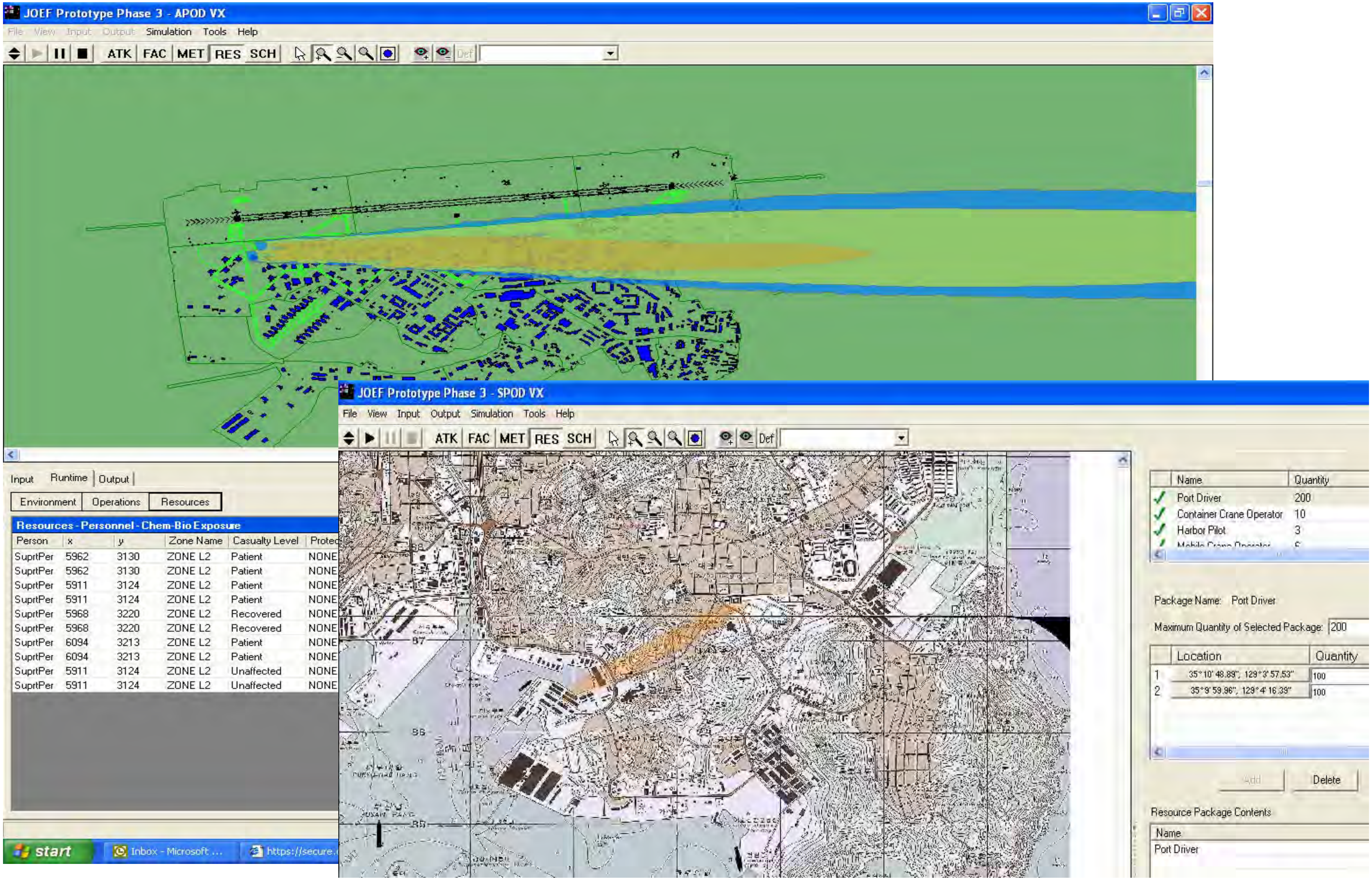
Workflow Management

- **Workflow Manager (WFM) module semi-automates and manages the multi-step processes used to produce various planning products such as Plans, Reports, and Assessments**

Activity Automation

- **Activity Automation (AA) Module semi-automates the creation of individual work products for tasks defined in a JOEF Workflow Manager process model**

Analytical Simulation Tools



Increments II and III:

(CBRN Event)

Incident Response & Consequence Management (Military, Civilian)

JOEF Consequence Management

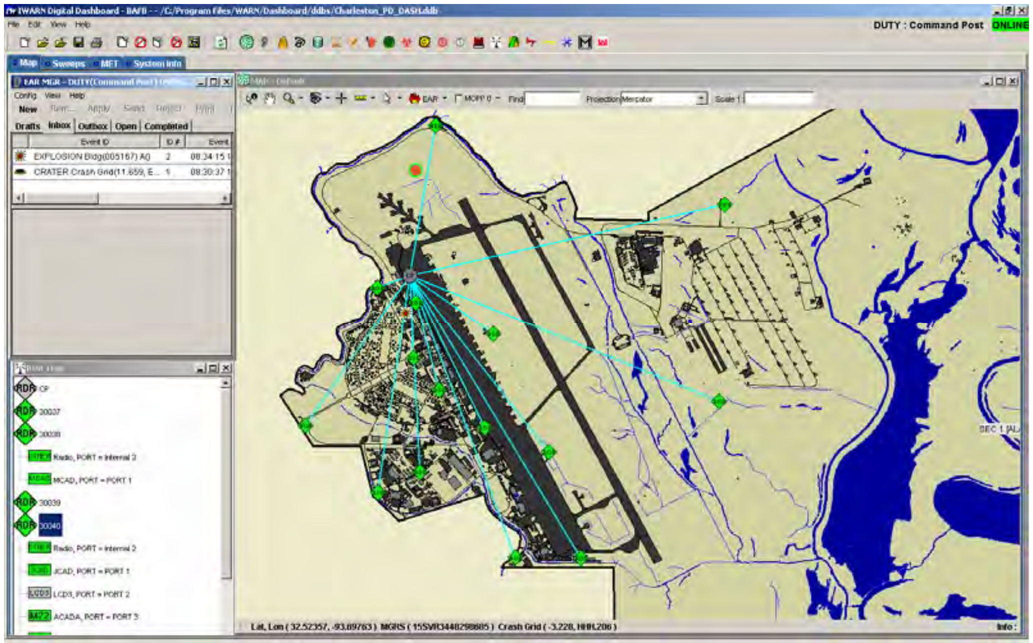


CHART	Light Work Level		
	Risk Assessment of Nerve Agent Exposure and Effect		
	Threshold Risk (Th)	Incapacitation Risk (EC)	Lethal Risk (LC)
Risk @ Calculated Dosage	<16%	<16%	<16%
Dose Required for Percentile Response	Th16 Dose (mg-min/M3) 0.2725	EC16 Dose (mg-min/M3) 19.86	LC16 Dose (mg-min/M3) 28.89
Calculated Dosage (mg-min/M3)	0.2700	0.2700	0.2700
	Moderate Work Level		
	Risk Assessment of Nerve Agent Exposure and Effect		
	Threshold Risk (Th)	Incapacitation Risk (EC)	Lethal Risk (LC)
Risk @ Calculated Dosage	>70%<84%	<16%	<16%
Dose Required for Percentile Response	Th84 Dose (mg-min/M3) 0.2936	Th16 Dose (mg-min/M3) 9.93	Th16 Dose (mg-min/M3) 14.44
Calculated Dosage (mg-min/M3)	0.2700	0.2700	0.2700
	Heavy Work Level		
	Risk Assessment of Nerve Agent Exposure and Effect		
	Threshold Risk (Th)	Incapacitation Risk (EC)	Lethal Risk (LC)
Risk @ Calculated Dosage	>84%	<16%	<16%
Dose Required for Percentile Response	Th84 Dose (mg-min/M3) 0.1957	Th16 Dose (mg-min/M3) 6.62	Th16 Dose (mg-min/M3) 9.63
Calculated Dosage (mg-min/M3)	0.2700	0.2700	0.2700

- **General Purpose CM tools, plus user-specific tools**
  - **General Purpose Tools: GIS interface, maps, geo-spatial analysis capabilities**
  - **User-Specific Tools: Sweep tools, CHART, ChemRat, etc.**

Science and Technology

JSTO/JOEF Collaboration

- Five JSTO/JOEF Technology Transition Agreements (TTAs) established in FY06
  - Integrated Information Management System (IIMS)
    - Successful Technology Transition Readiness (TTR) Review and Transitioned into JOEF PO – Completed Sept 06
    - Use IIMS as-is in Build 1; Will convert its JOEF-related major functionalities into Service Oriented Architecture (SOA) for Build 2
  - Model of Chemical IED Effects on Mobile Forces
  - Improvements in CBR Operational Effects Modeling Tools and Methods
  - Internal Modeling Capability for Staffs
  - Next Generation Model of CB Effects on Military Operations

JSTO/JOEF Collaboration
(Continued)

- **Sensor Placement Technologies from ITT and DSTL-UK**
  - Request JSTO assistance in evaluating rule-based and optimized sensor placement technologies for inclusion in JOEF Increment I
  - JOEF Build I will use ITT's Automated Rules-based Placement (ARP) implementation; Expand/upgrade sensor placement capability as improved methods become available
- **Automated Coalition Consequence Management (ACCM) Advanced Technology Demonstration (ATD), FY07/08**
  - USPACOM sponsors the Multinational Planning and Augmentation Team (MPAT) to explore Automated Coalition Consequence Management (CM)
  - Plan to use JOEF for CM capabilities

JOEF Future S&T Needs

- **Automation, Optimization and Integration**
  - Use of optimization for rapid, reliable, robust CBRND COA planning, resource allocation and placement
  - Task automation and artificial intelligence for CBRN staff support.
  - M&S federation automation, tools to automatically negotiate CBRND FOMs
  - CBRN synthetic environment for training, exercises, and experiments
  - Methodology and tools for rapid generation of operational execution checklists and templates
  - Automated tools to discover and predict COA vulnerabilities
  - Integration of CBRN effects models with campaign warfare models.
  - Modeling tools for mobile force CBRND operational impacts
  - Framework for integration of CBRND planning tools with incident/consequence management
- **Models and Data**
  - TIC/TIM human effects and task-time-theater information
  - Radiological and Nuclear Effects Models
  - Medical resource limitation effects
  - Secondary infection models and bio threat characterizations to assess contagious disease control plans and policies
  - MOPP task degradation data for “non-standard” MOPP conditions and additional task types

Questions?

POCs: **Dr. Jerome Hoffman** **jerome.hoffman@jpmis.mil**

Kathy Houshmand **kathy.houshmand@jpmis.mil**

IMPACT Framework

Mr Andrew Howe (Dstl)

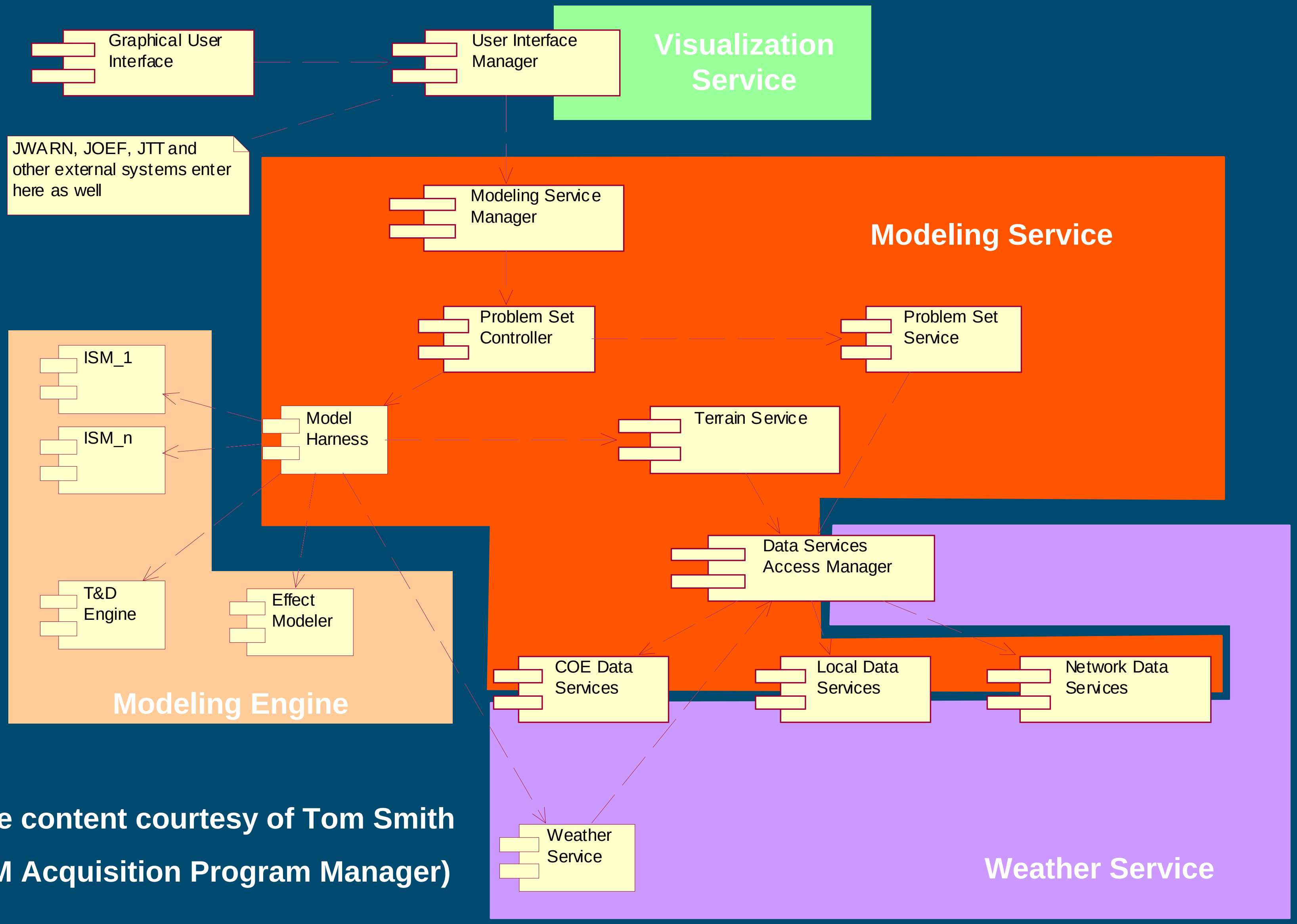
Programme Overview

Work programme initiated September 2006.

"To use the modelling capabilities developed by Dstl as a testing environment for the purposes of identifying best of breed techniques and to allow the exploration of architectural and Service Oriented Architecture (SOA) requirements and limitations that are likely to be encountered by the US Programs of Record (JEM, JOEF and JWARN), including an exploration of distributing the computational burden associated with running simulations, evaluating potential gains and proposing how they could be implemented into the software architectures of the Programs of Record."

Programme Background

- A strategy for data interoperability between the Programs of Record is already in place:
  - DoD Net-Centric Data Strategy.
- Mechanisms of achieving the goals of the strategy are under development:
  - JPM-IS CBRN Data Model.
  - JPM-IS CBRN XML Schema.
- The respective architectures of the Programs of Record are well defined.



Slide content courtesy of Tom Smith

(JEM Acquisition Program Manager)

Focus & Challenge Overview

- “Inside” the Modelling Engine (JEM)
  - Dispersion calculations are computationally demanding:
    - Meteorological conditions.
    - Complex terrain interactions.
    - Building interactions (urban environment).
    - Large domains (e.g. biological release).
  - Hardware resources are limited:
    - Limited processing power.
    - Limited communications bandwidth.

- Are there therefore any advantages / disadvantages to distributing the models that constitute a model run / simulation?

Software Challenges

- Hardware limitations:
  - Application throughput:
    - Memory
    - CPU usage
    - Communications latency
- 32 bit Operating System limitations.
- Interoperability with legacy code bases.
- Reliability / maintainability.
- Scalability.
- Security.
- Others anticipated as the programme progresses…

Dispersion Modelling Solutions

- Use of a Gaussian Puff Model:
  - Distributes particles over a 3D area, which enlarges and “thins out” as the puff moves downwind.
  - Less computationally demanding (memory and CPU) than models that process individual particles.
    - Enables calculations to run in a shorter duration over a larger domain.
- Adaptive grids:
  - Allows for greater puff fidelity in the vicinity of the source, which reduces as the puff moves downwind.

- These are “well known” solutions to challenges faced by the CBRN community (implemented e.g. in SCIPUFF).

Dispersion Modelling Solutions

- Elimination of “Opportunistic Calculations”:
  – CPU cycles are not “wasted” calculating, and then recalculating a result based on data that may have changed.
- Deletion / serialization of “non-output” puff histories.
- Modifiable “puff splitting” (higher resolution, greater computational cost) and “puff merging” (lower resolution, lower computational cost).
- Caching of coordinate conversions.

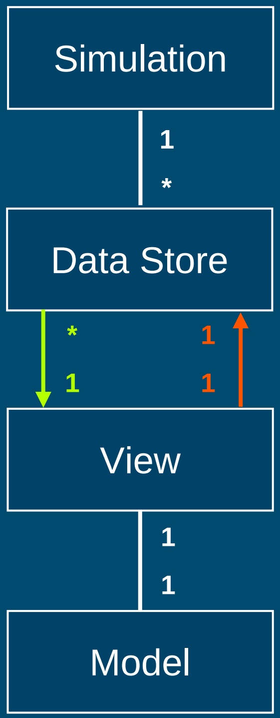
“Test Bed” Architecture

- A framework for the integration of separate models into a single coherent simulation.
  - Orchestrates the flow of data between models i.e. the system is “aware” of the dependencies between the models that constitute a simulation.
  - Decouples models by design (i.e. the models communicate with the system, not with each other, meaning that each model requires knowledge its own of data, but not how, or from where, it was created.)
  - Data streams or files can be used to replace models.

- Provides a “sand box” where concepts may be rapidly prototyped.

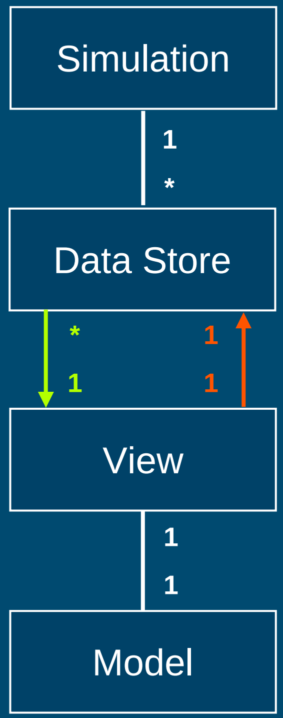
Model Concepts

- A model is essentially an “atomic” process (i.e. consumes data, processes it, and generates a result).
- Each model is controlled by the system (i.e. instructed to progress to a point in simulation time).
- Each model has a limited view of the environment in which it is executing.



View Concepts

- A view provides an interface to a shared set of data stores that contain all of the data used by a simulation:
  - get(entity, attribute, time) : value
  - set(entity, attribute, time, value) : void
- Each view has access to zero or more read only data stores.
- Each view has access to a single writable data store.

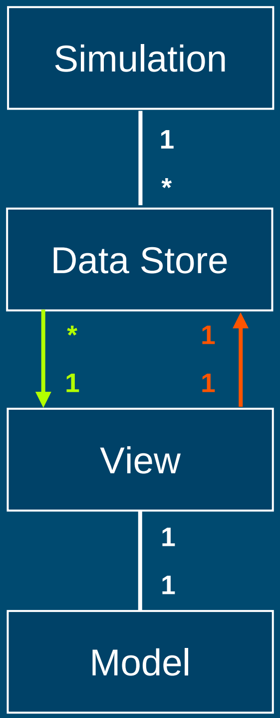


Data Store Concepts

- All data is stored in the form of discrete entities, each of which has at least one attribute.
- Each attribute has a time series of values stored in the data stores as a mapping, such that they may be referenced by the key:

  entity + attribute + time → value

- Once written to a data store, data is immutable.



Concurrency

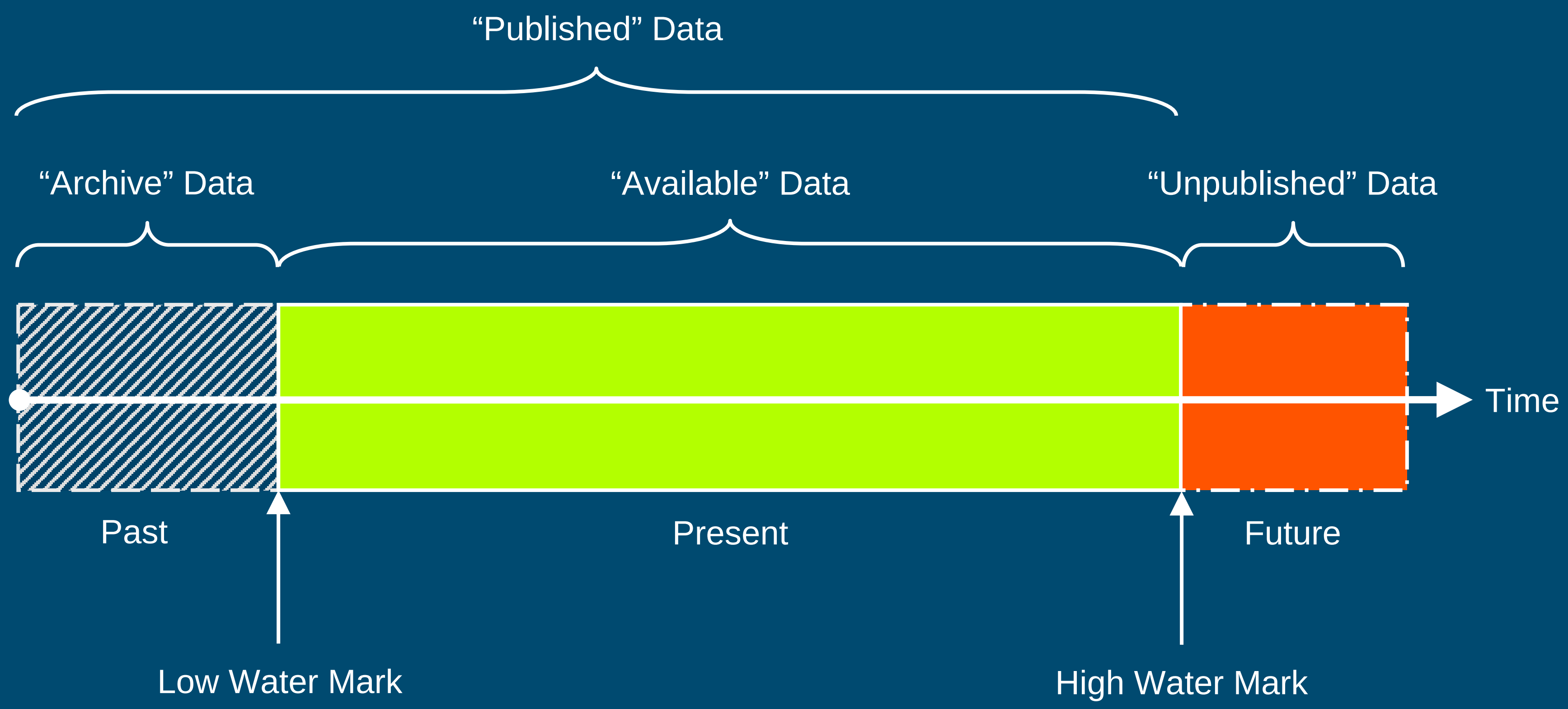
- When distributed, the system may be represented as a classical Readers & Writers problem:
  - Shared resources (Data Stores), each of which is accessed by *N* “reader” processes and a “writer” process (models (via views)).

- “Safety” Property
  - Writers *must* have exclusive access to the shared resource.
  - Many readers may access the shared resource when no writers are active.
- “Liveness” Property
  - Reader and writer processes *must* be able to gain access to the shared resource eventually.

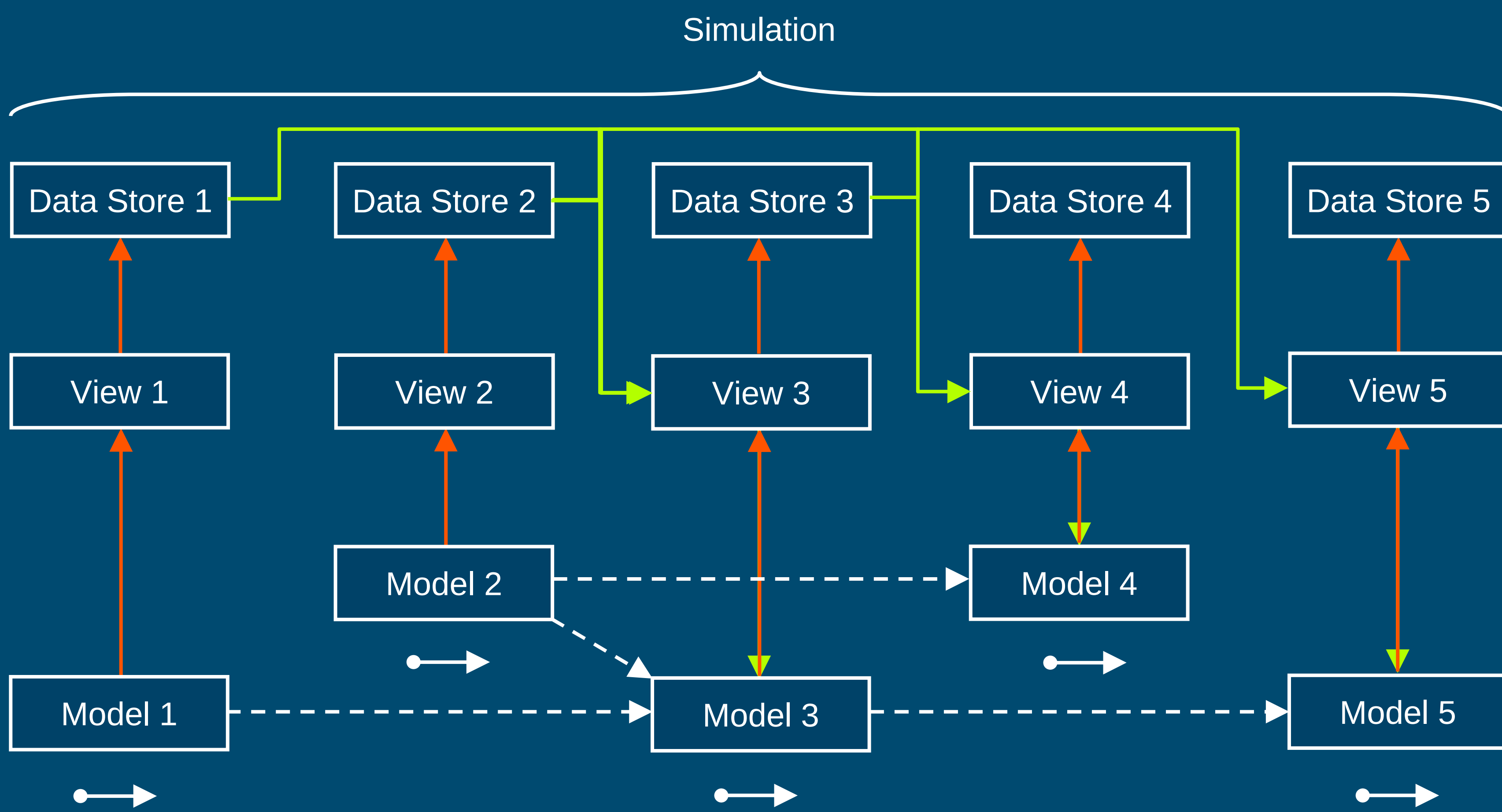
Concurrency

- Traditional solutions to the Readers & Writers problem involve implementing the Data Stores as “monitor” objects:
  - Readers Priority.
  - Writers Priority.
  - Fair.
- These result in a performance bottleneck located around the Data Stores.

Data Store Detail

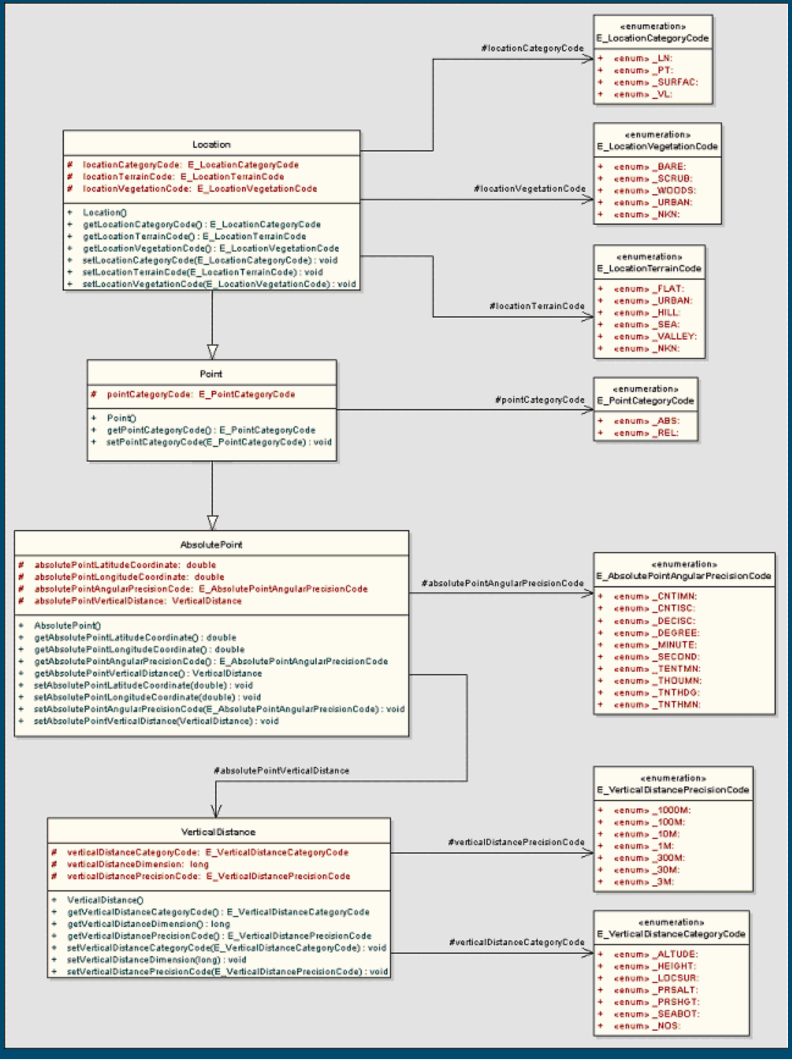


Simulation Overview



CBRN Data Model Considerations

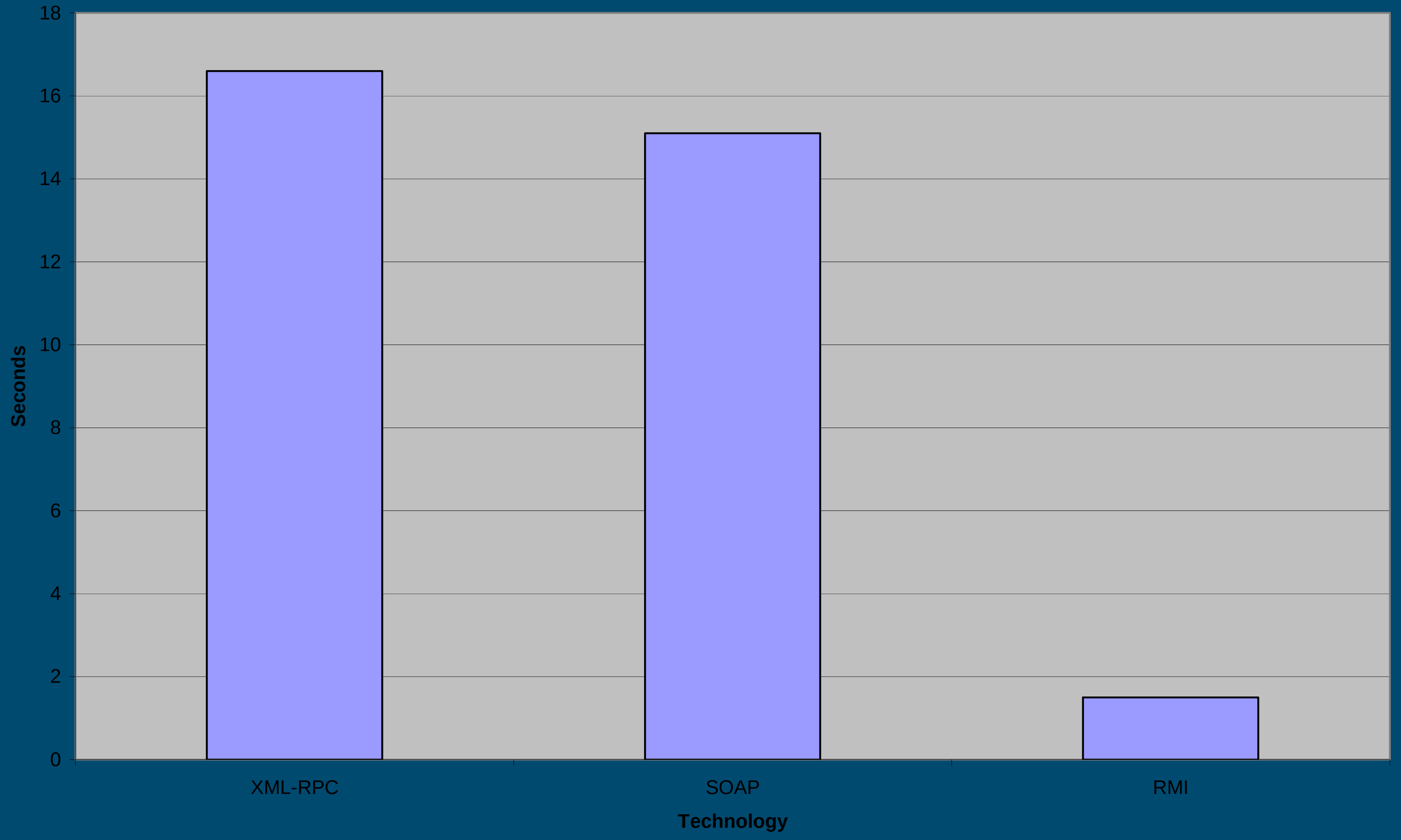
- A prototypical Java implementation of the CBRN Data Model has been developed as part of an internal Dstl effort.
- “Location” (no “MetaData” shown).



Observations

- Comparison of XML-based protocols (SOAP, XML-RPC) and Java RMI for distributed model → model interactions (NB not system → system!) performed.
- Measurements included:
  - Time (seconds) to send 100,000 “Location” objects from one process to another and back.
  - Volume of data (bytes) to send 100,000 “Location” objects from one process to another and back.
  - Percentage CPU usage (one end only) to send 100,000 “Location” objects from one process to another and back.

Observations (Time)



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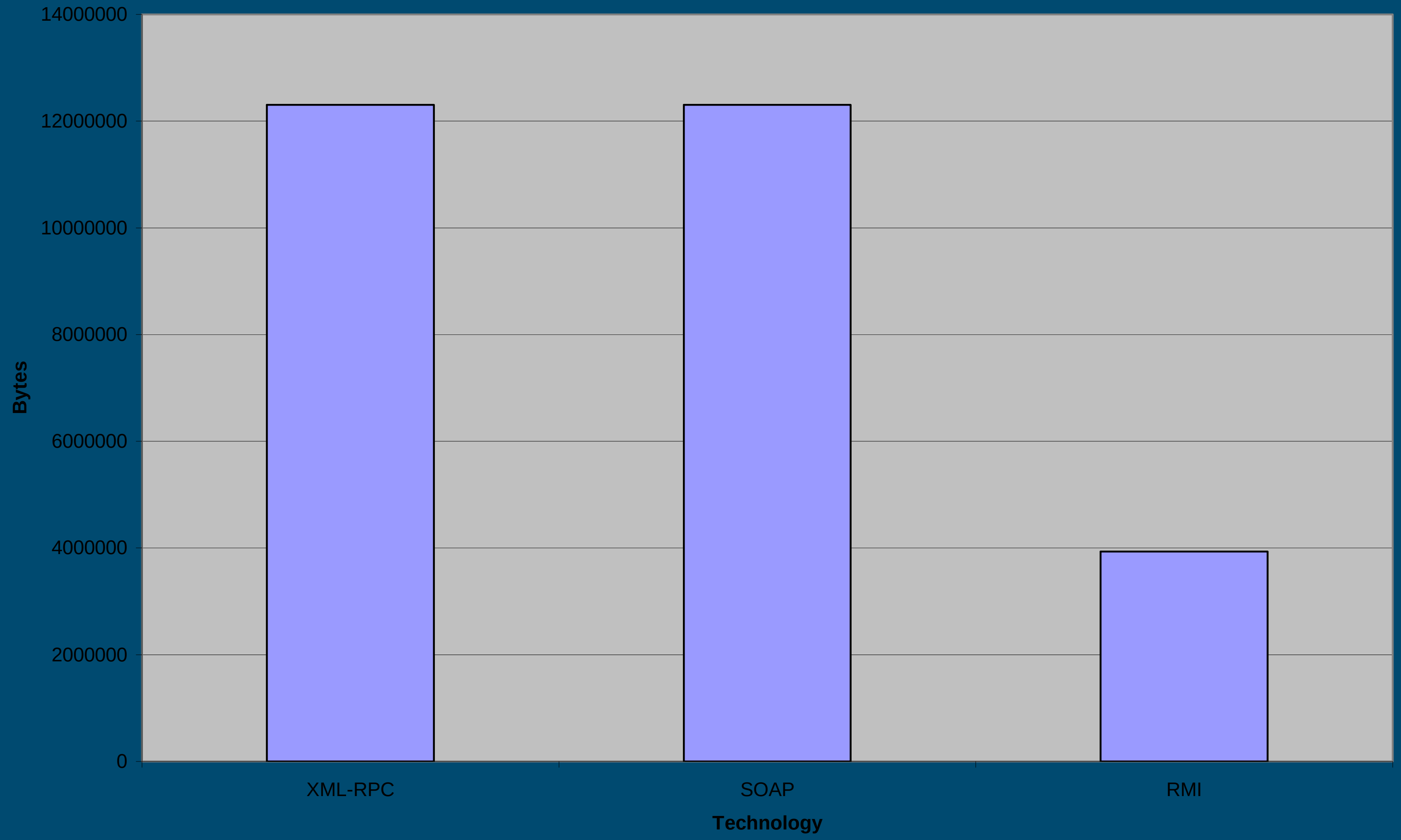
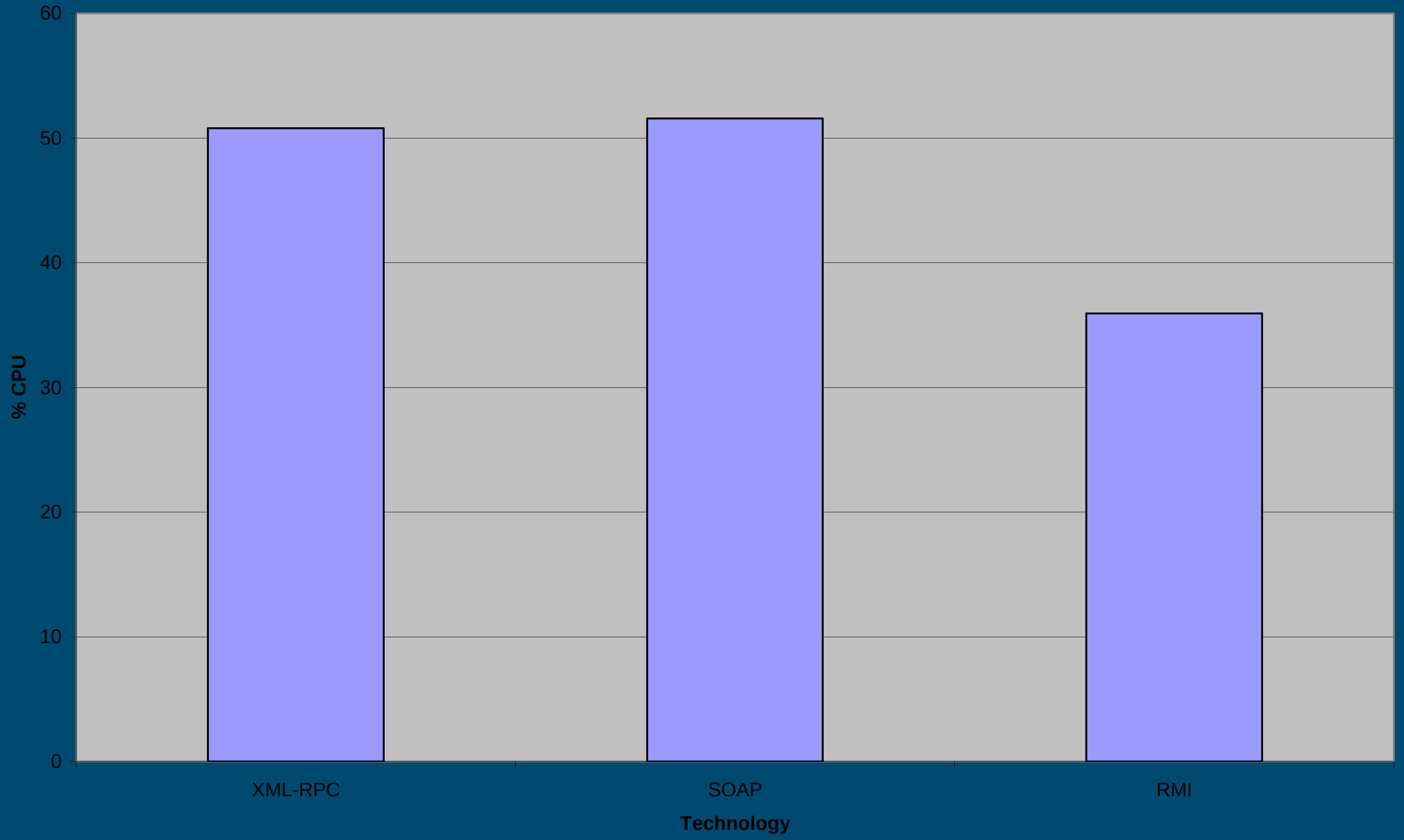
Observations (Volume of Data)



Observations (% CPU)



Future Work

- Identification and development of a necessary and sufficient set of CBRN Data Model-compliant web services that can interact with the system previously outlined.
- Examination of future modelling requirements with respect to identifying opportunities for distribution and concurrent execution of individual models:
  - JEM
  - JOEF
  - JWARN

Questions?

A Bayesian Approach for Estimating Outbreak Characteristics from Patient Data

Abstract # 4469

J. Ray, Y. M. Marzouk, M. Kraus and P. Fast

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NORAD-NORTHCOM, Colorado Springs, CO
Lawrence Livermore National Laboratory, Livermore, CA

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
for the United States Department of Energy's National Nuclear Security Administration
under contract DE-AC04-94AL85000.

Problem and motivation

- **Consider a bioattack**
  - **Atmospheric release of an aerosolized pathogen**
    - **Not caught on sensors**
    - **Not terribly big – $O(10^3)$ infected people**
  - **First intimation : successful diagnosis of an infected individual**
- **The technical challenge**
  - ***Infer (τ, N, <D>)***
  - ***Inputs: $\{t_i, n_i\}$, $i = 1 \ldots M$*, time series of new symptomatics every day / every 6 hrs.**
- **Restrictions**
  - **Can only use 3-4 days of data, past 1st diagnosis i.e. M is small**
  - **Quantify uncertainty due to incomplete observation / limited data**
  - **Noise – stochastic data**
  - **Expect model errors – i.e. model (used for inference) is approximate**

Methodology

- **Research Challenge**
  - Little prior work – 2 published papers on the general topic
  - No contagious diseases, simplified models for non-contagious ones
  - All recent publications (oldest is 2004)
- **Bayesian Inference**
  - Likelihood Λ of observing a $\{t_i, n_i\}$, sequence given a (τ, N, <D>) attack can be analytically derived [1]
  - Exploits the dose-dependent incubation period distribution of a disease

$$P\left(N,\tau,\langle D\rangle \mid \{t_i,n_i\}\right) \propto \Lambda\left(\{t_i,n_i\} \mid N,\tau,\langle D\rangle\right)\pi_N(N)\pi_\tau(\tau)\pi_D\left(\langle D\rangle\right)$$

- **Simulated aerosol attacks to generate data**
  - Assume a city with a generic population distribution
  - Lay down a plume, infect people with different dosages
  - Dose dependent anthrax incubation period models [2; stochastic !]
  - Sources of errors – noise, model errors, incomplete observation
- **Also invert the Sverdlovsk anthrax incident of 1979**

1. Ray et al, Sandia Technical. Report., SAND2006-1492
2. Wilkening, PNAS, 103(20):7589-7594, May 2006.

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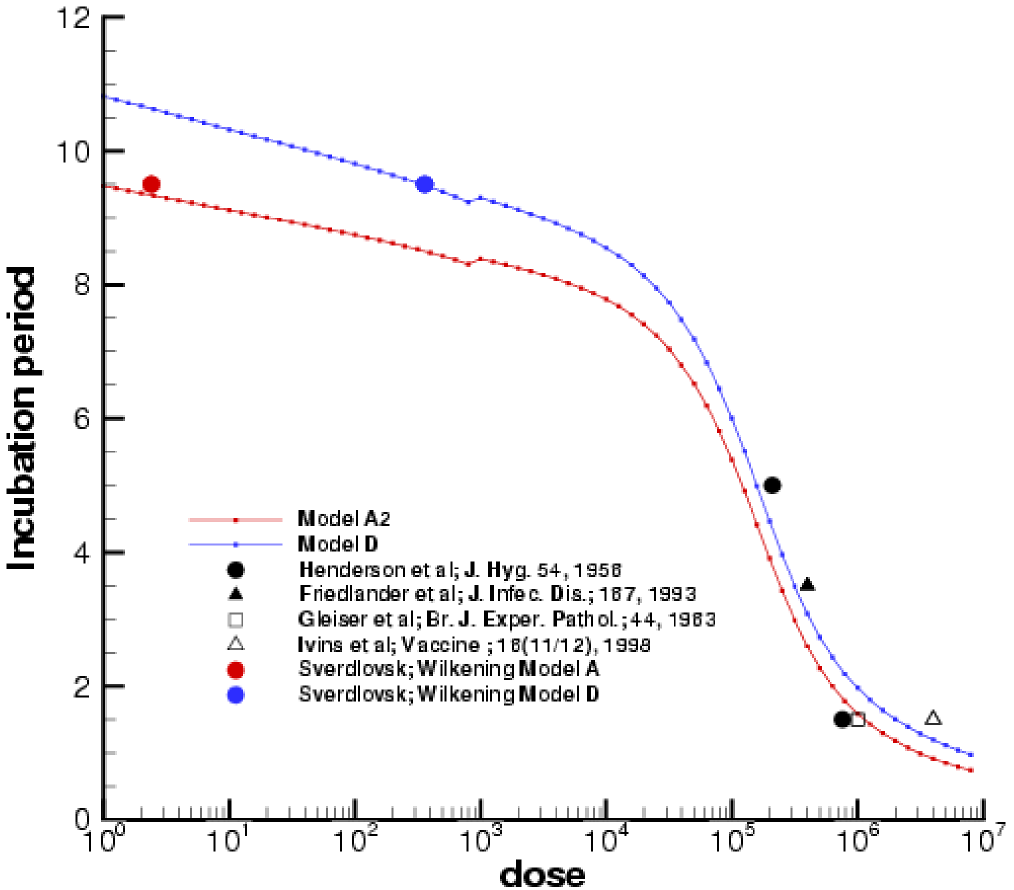
Anthrax incubation period models

- Spores are subjected to competing processes
  - Clearance by immune system and germination into vegetative cells (rates obtained from non-human primate expts.)
  - PDF for time to germination (PDF #1)
- Vegetative cells reproduce at various rates (random variable)
- A threshold number of vegetative cells triggers symptoms
- Time from germination to symptoms, s, has a log-normal distribution (PDF #2)
- Convolution of PDF # 1 and PDF #2 gives incubation period distribution
- Parameters calculated from non-human primate experiments and Sverdlovsk, 1979.

Attack and inference models



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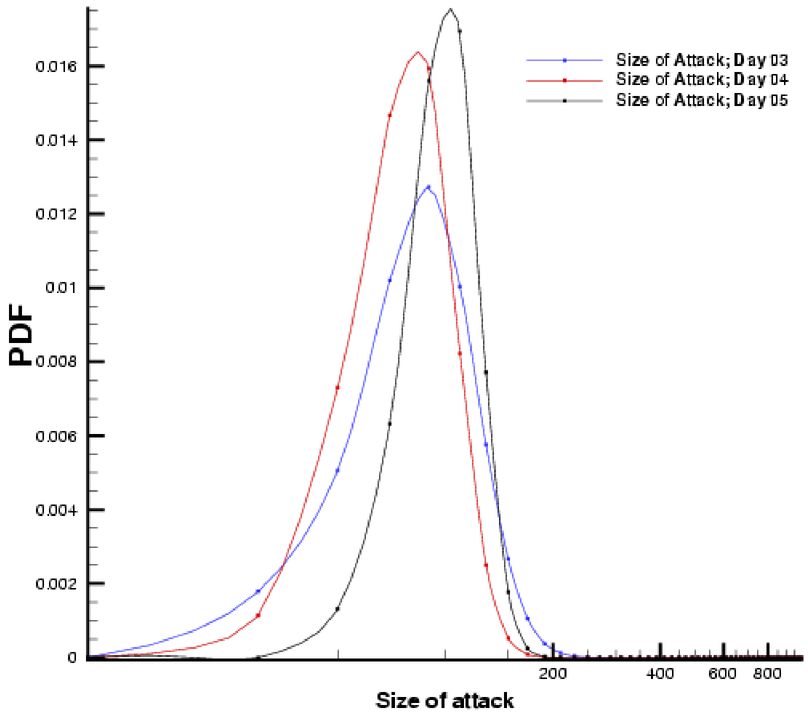
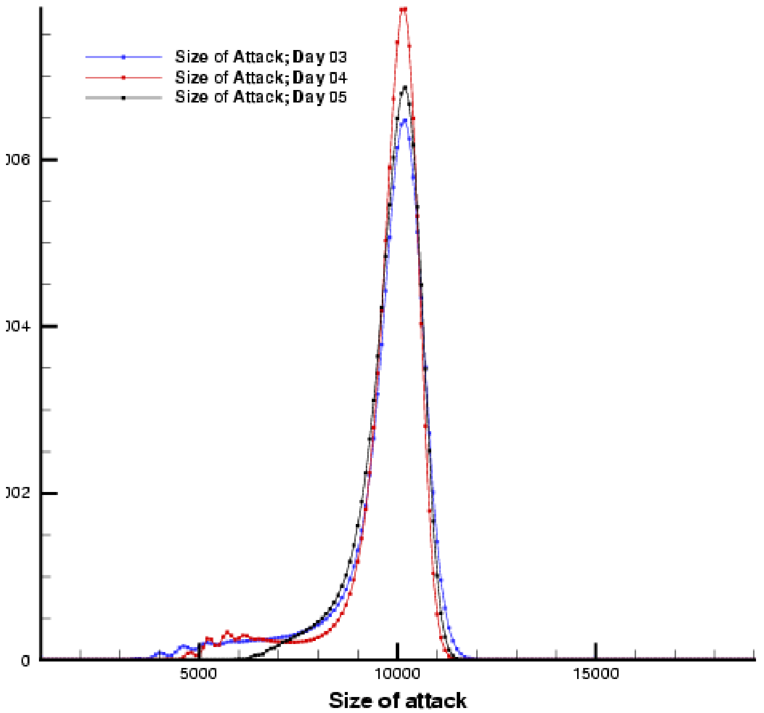
Check No. 1 – Ideal case

- Does the method work in the ideal case?
- Approach :
  - Simulate 2 “ideal” attacks
    - Case B : 100 infected people
    - Case E : 10,000 infected people
  - Every infected person receives a dose of 100 spores
  - The disease progresses as per the blue model
  - Collect observations (# of symptomatic people) over 6-hr intervals
  - Inference as per blue mode too
    - No model errors !
  - Infer characteristics of attack based on 3-5 days of data
- Discrepancy between characterization and simulation due to:
  - Noise in the observations
  - Incomplete observation

Inference of size of attack



Case B : N = 100, τ = -2.25, $\log_{10}(D)$ = 2



Case E : N = 10,000, τ = -1.0, $\log_{10}(D)$ = 2

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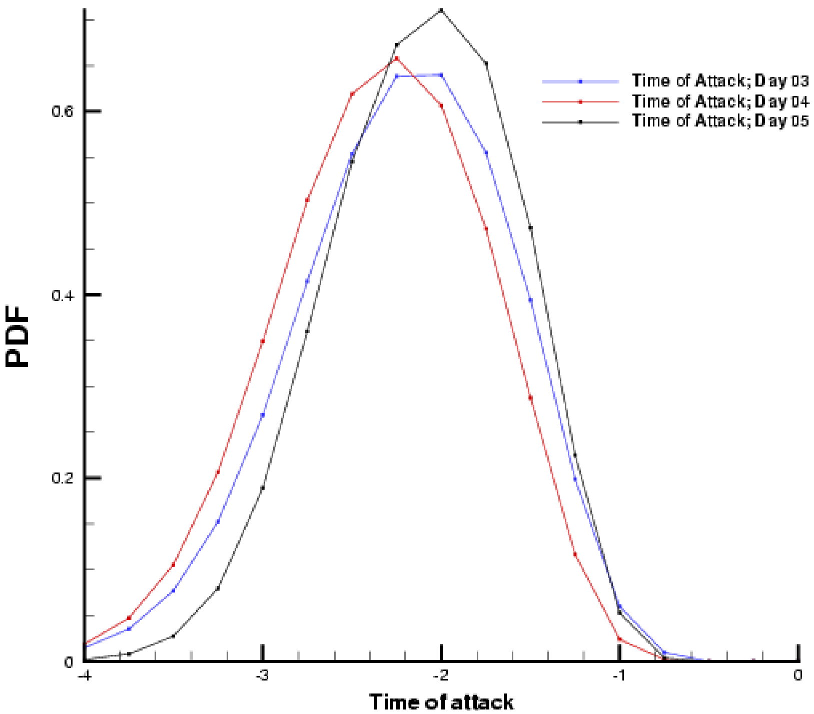
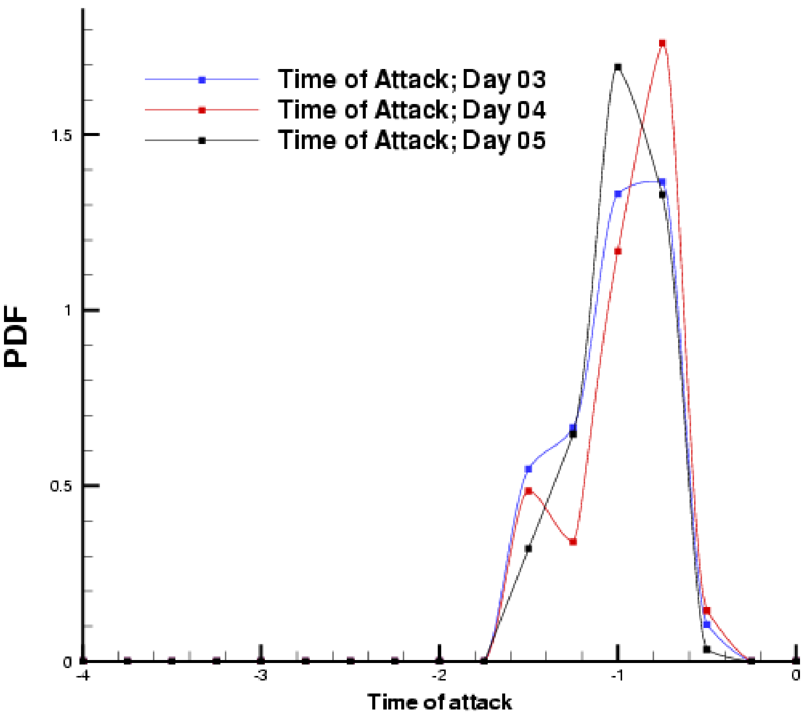
Inference of time of attack



Case B : N = 100, τ = -2.25, $\log_{10}(D)$ = 2



Case E : N = 10,000, τ = -1.0, $\log_{10}(D)$ = 2

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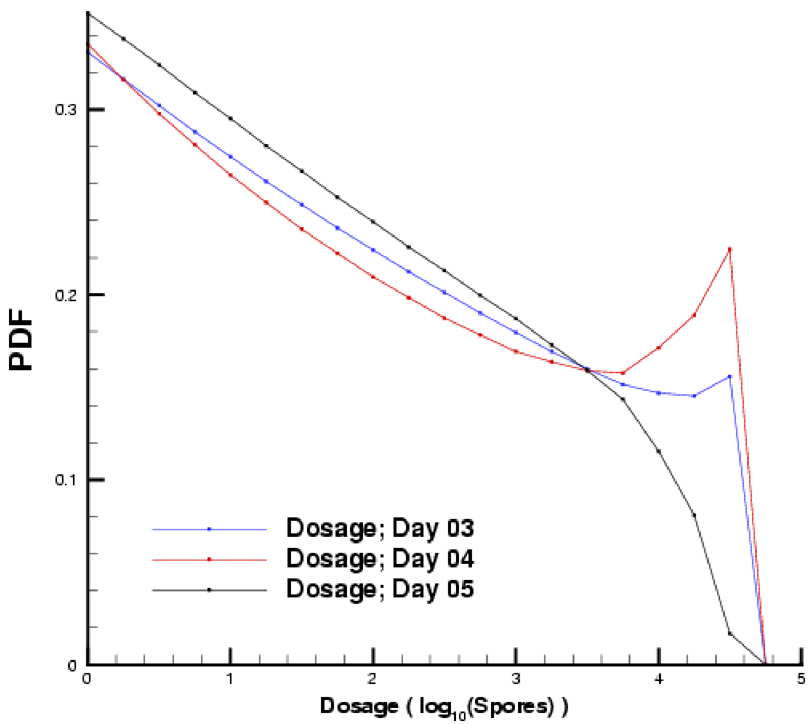
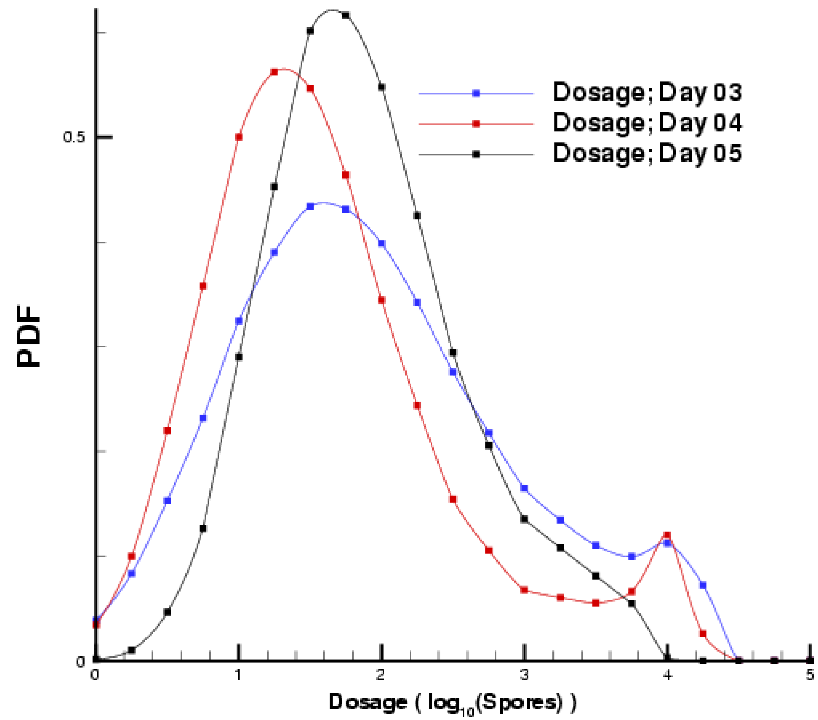
Inference of dosage received during attack



Case B : N = 100, τ = -2.25, $\log_{10}(D)$ = 2



Case E : N = 10,000, τ = -1.0, $\log_{10}(D)$ = 2

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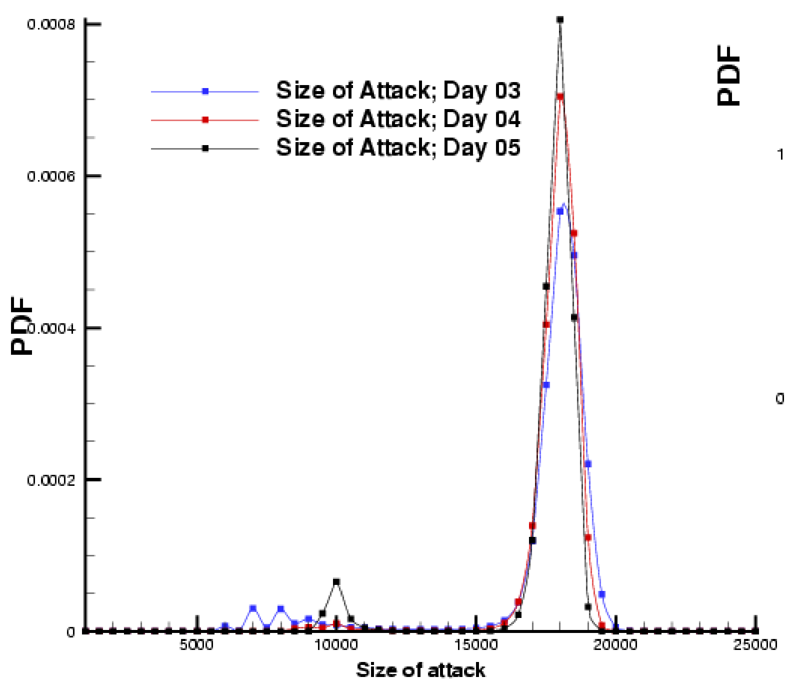
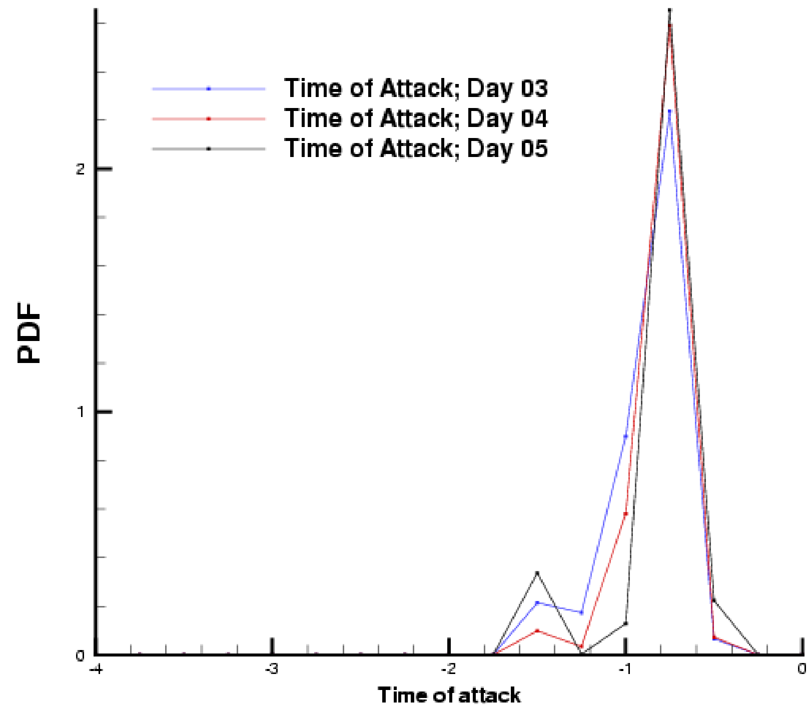
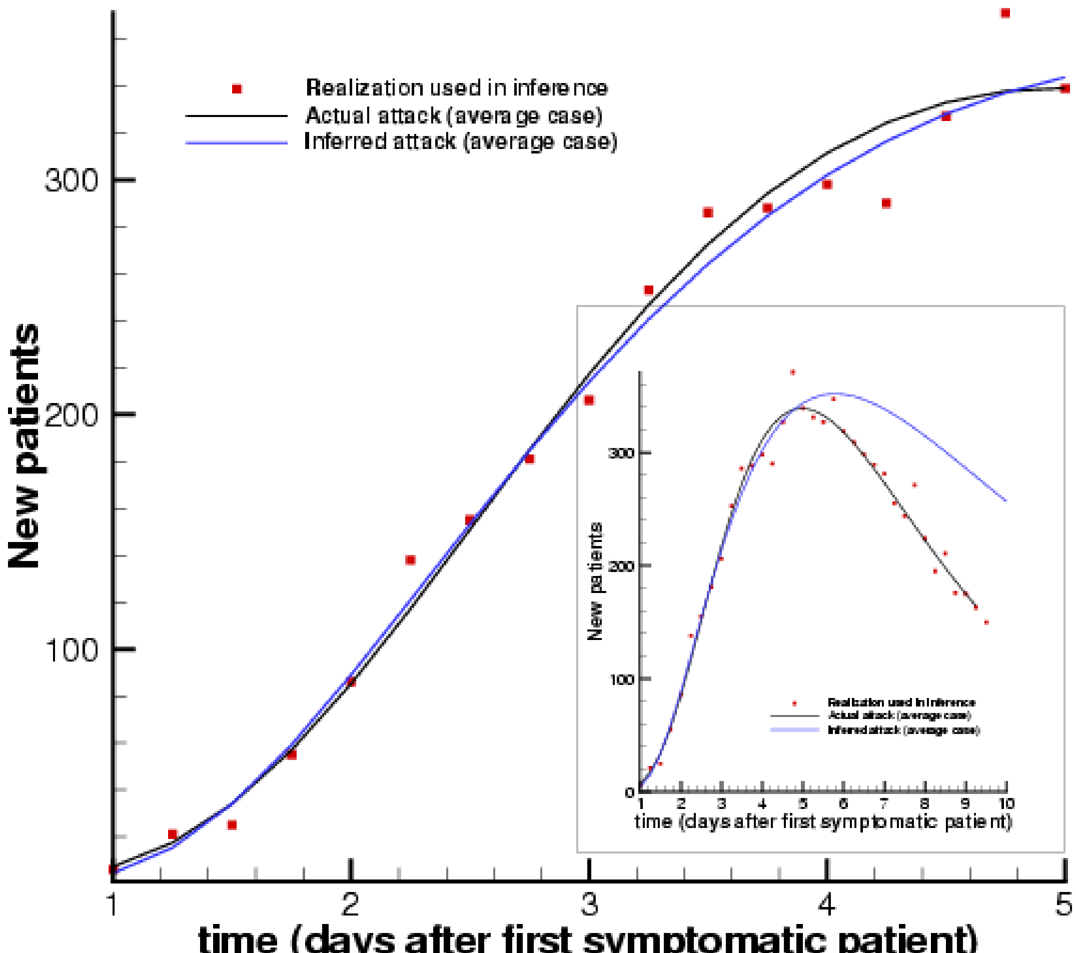
A spectacular failure

- Inferring with partial observations can lead to spectacular failures
- Time series : {2, 369, 938, 1102, 958}
- Attack : N = 10^4, τ = - 1.5, D = 10^4





Why?



Realization used in inference
Actual attack (average case)
Inferred attack (average case)
300
200
100
1
2
3
4
5
New patients
time (days after first symptomatic patient)
New patients
time (days after first symptomatic patient)

Synopsis of the first check

- **Given ideal case (accurate model and uniform dose), the inverse problem**
  - **Reliably infers size and time**
  - **Dosage is hard for small attacks**
  - **Large attacks are easier to infer**
  - **Characterizations can go wrong when based on incomplete observations, *but....***
  - **Always recovers to correct one when more data becomes available.**
- **The method is mathematically consistent, *but….***
- ***Is it useful / applicable in non-ideal cases?***

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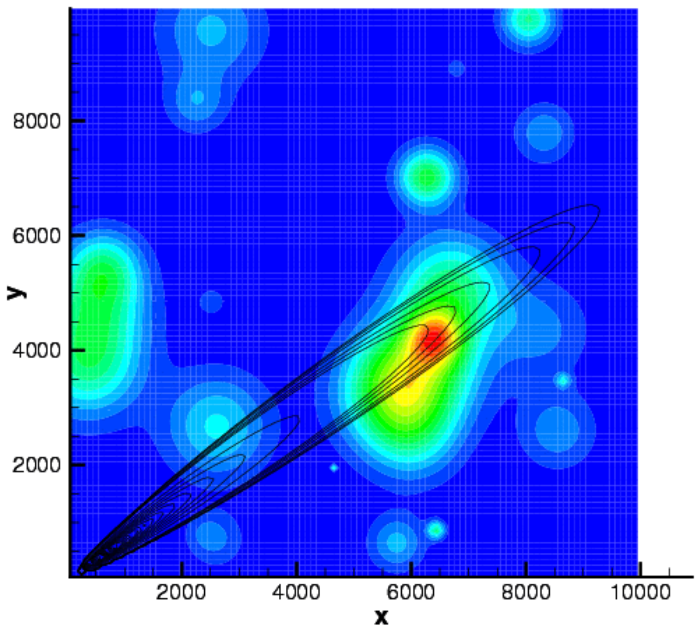
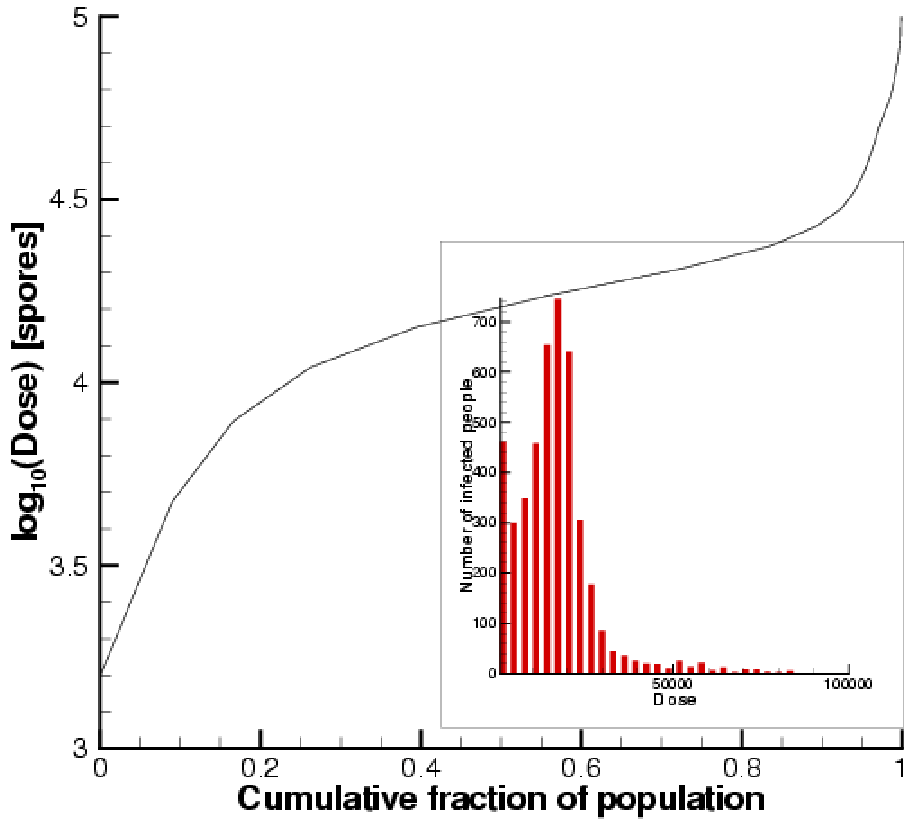
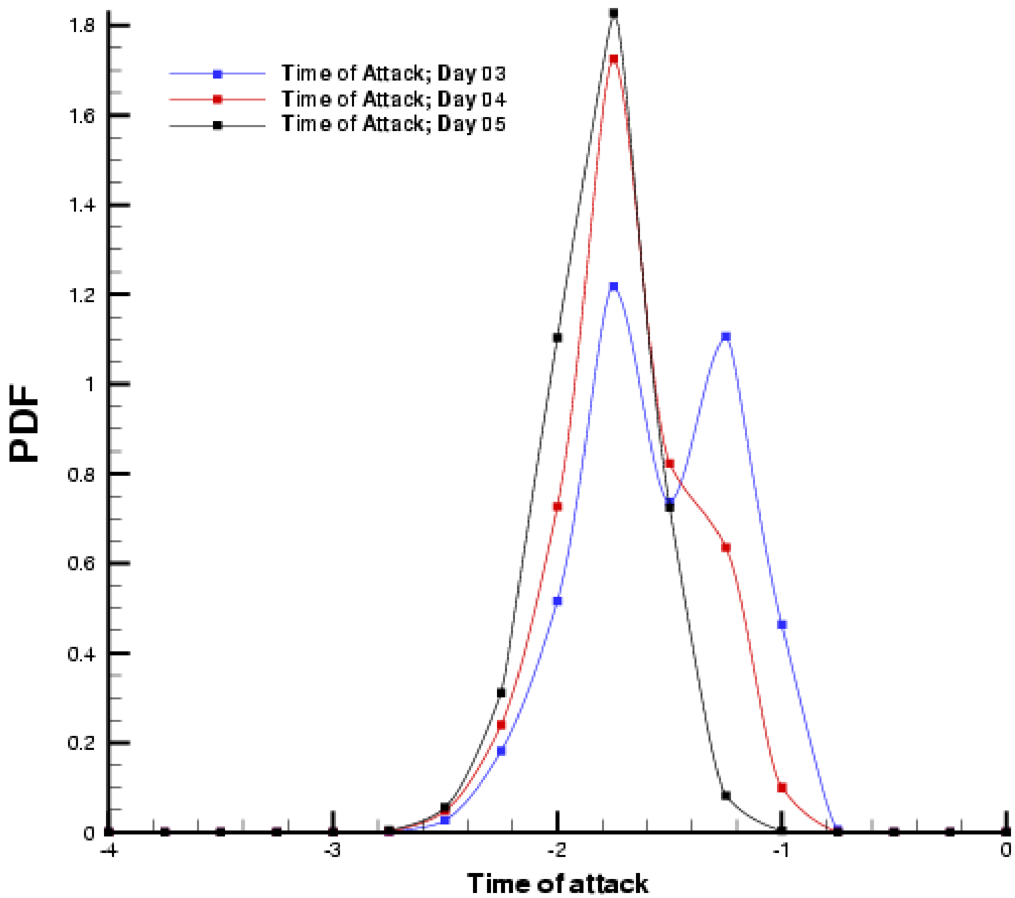
Simulated attack example

- **Simulated attack**
  - **Case: N = 453, t = -0.75, $\log_{10}(\langle D \rangle) = 4.23$**
  - **Time series: {1,36,57,55,56}**

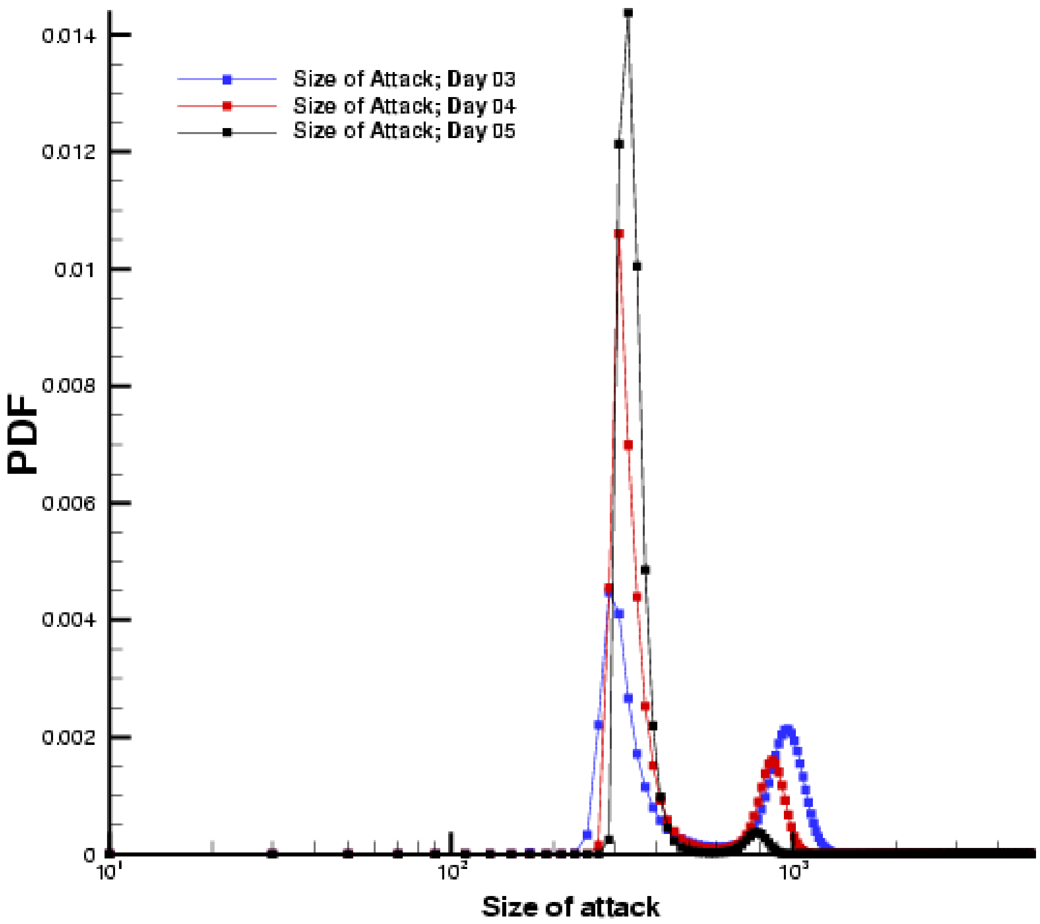




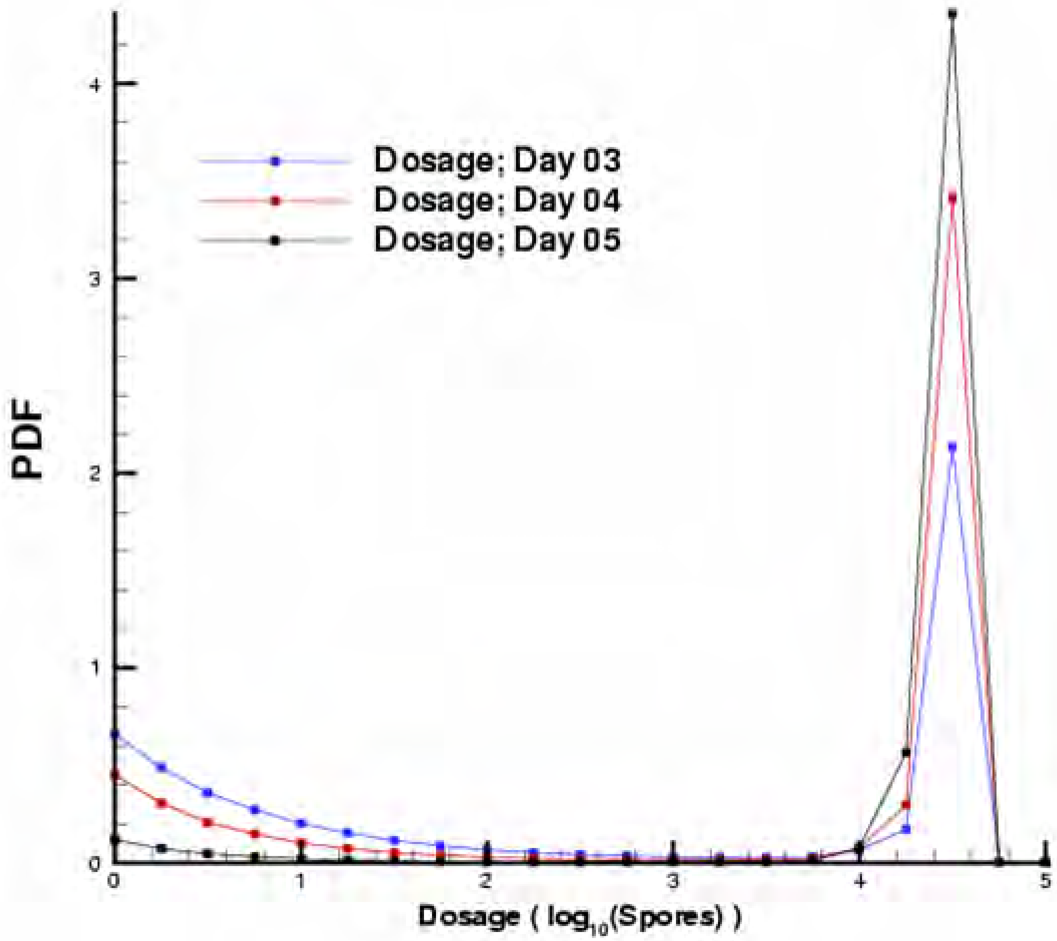
Comparison of inferred time



Comparison of inferred size



Comparison of inferred dosage



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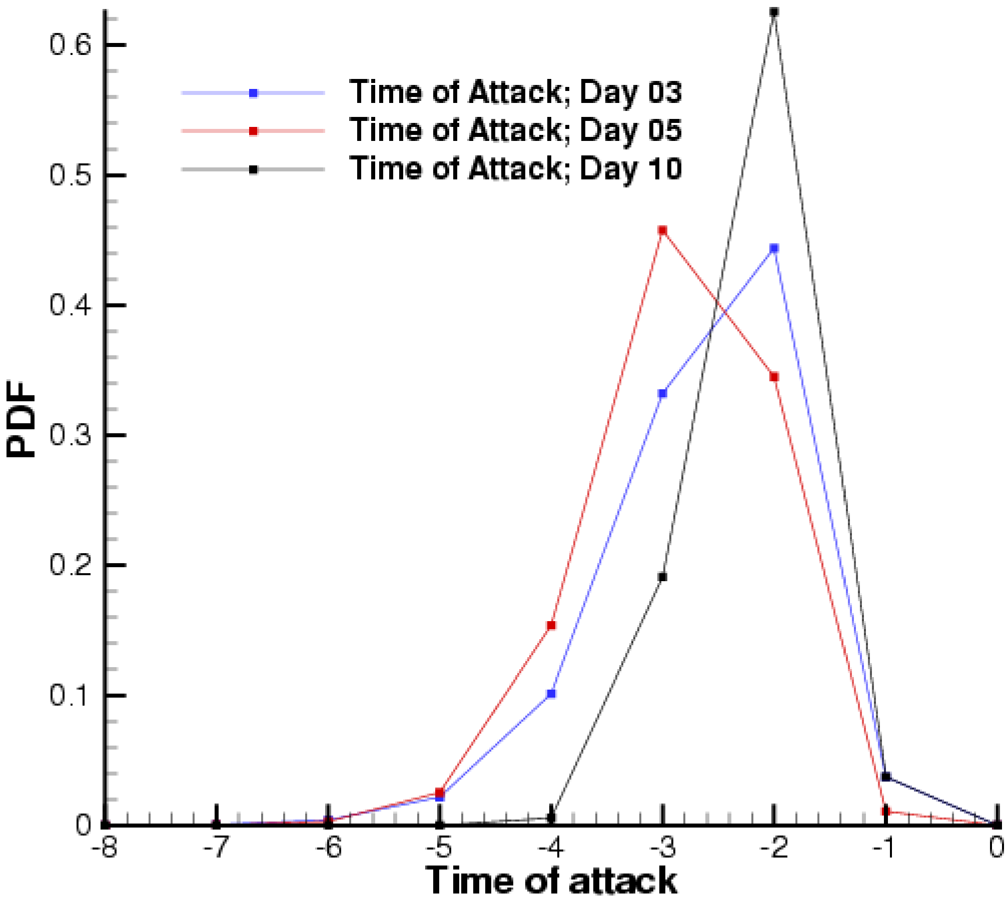
Sverdlovsk,1979

- Suspected atmospheric release of weapon-grade anthrax formulation from a military compound
  - Estimated date : April 2nd, 1979.
  - First symptomatic: April 4th, 1979
  - Estimated number of infected people: 75 ; 70 died
- Challenges
  - Small size
  - Reconstructed data
  - Low dose; estimated dose per person:
    - 9 spores (Meselson, *Science*, 1994, using Glassman's numbers)
    - 1-10 spores (Wilkening, PNAS, 103(20), 2006)
  - Effect of prophylaxis (initiated April 12th, 1979)
  - Vaccination (started : April 15th, 1979 (approx))

Sverdlovsk, 1979 - Time of infection



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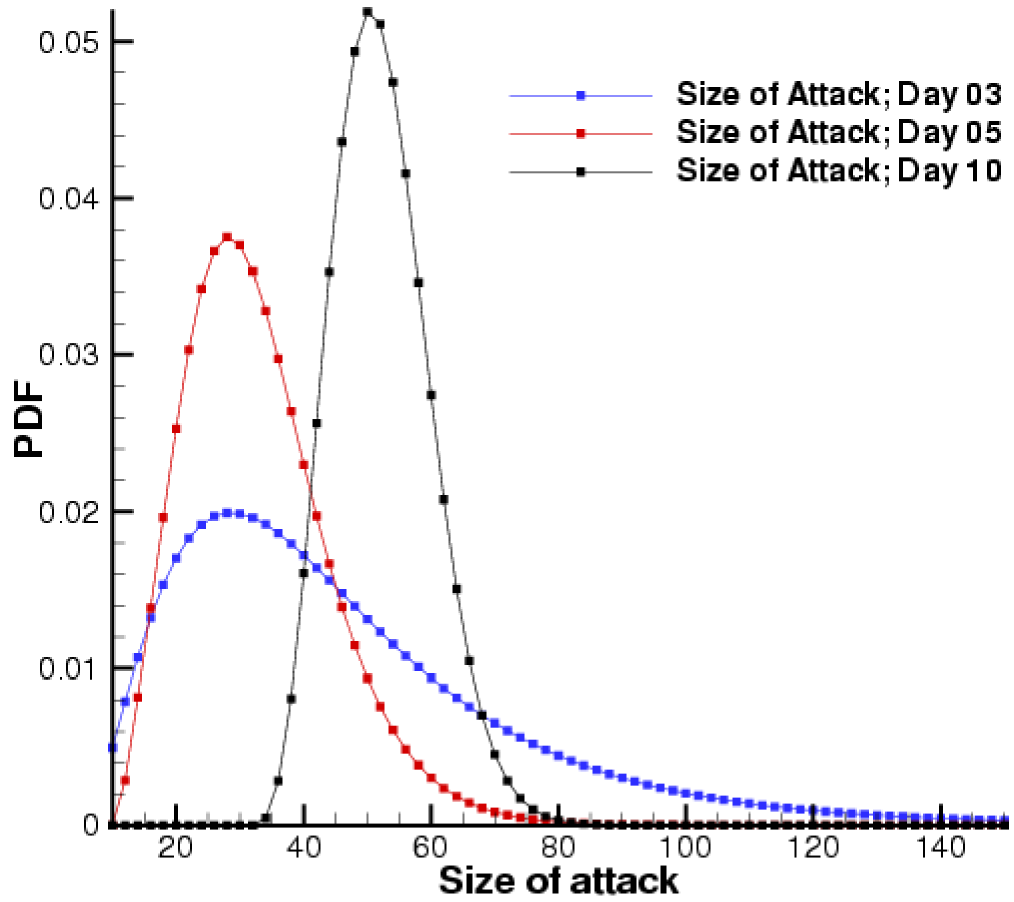
Sverdlovsk, 1979 – Size of infected population



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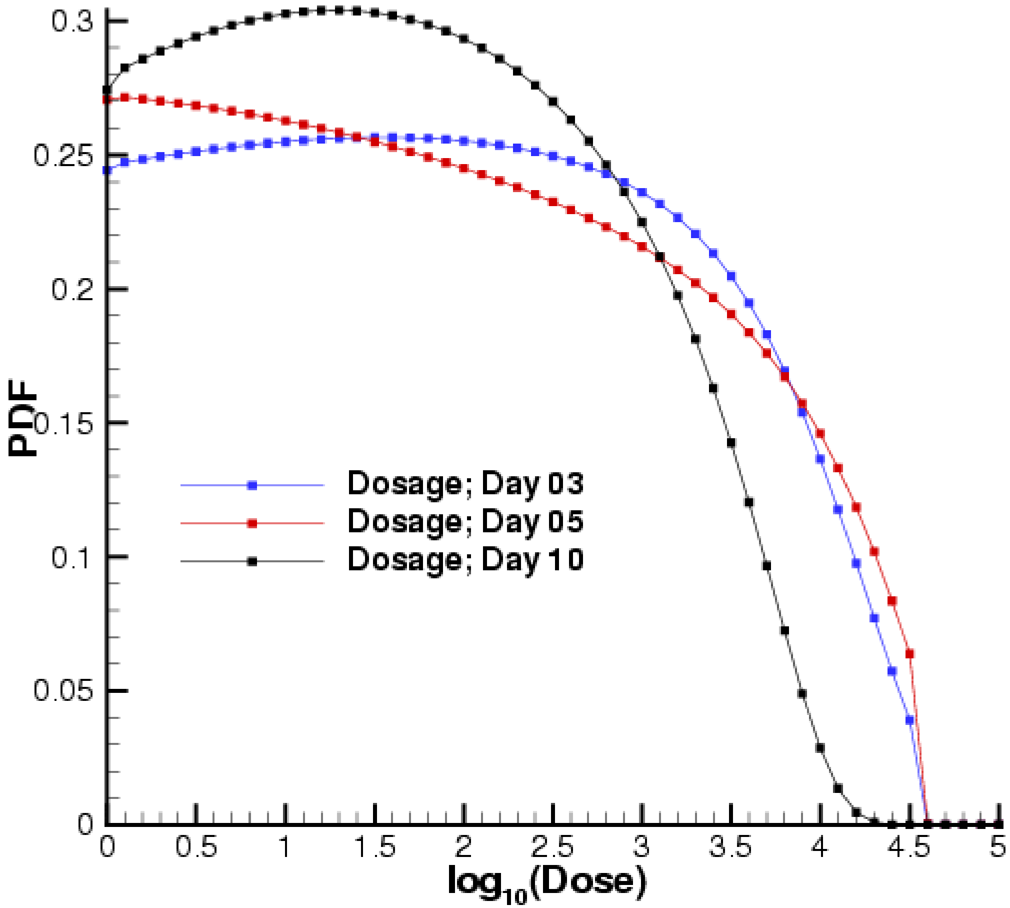
Sverdlovsk, 1979 – Dosage



Conclusions

- **We have**
  - A rigorous Bayesian formulation to characterize bioterrorist attacks (anthrax)
  - Can be extended to smallpox, plague and other disease with a *symptomatic* contagious period.
- **We need, in short order,**
  - To bring in a spatial component into the inverse problem,
  - Ditto, contagious diseases
- **Ultimately, need to design a risk-based response plan**
  - Characterization not very useful if the cavalry rides in every time someone sneezes.
- **More Information :**
  - Ray et al, "A Bayesian method for characterizing distributed micro-releases", Sandia Technical Report, SAND2006-7568, Printed December 2006. Unclassified, unlimited release.

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Chem-Bio Virtual Prototyping Benefit and Feasibility

2007 Chemical Biological Information Systems (CBIS) Conference

sponsored by

Joint Science and Technology Office – Chemical and Biological Defense

8-11 January 2007

Michael O. Kierzewski

R&T Directorate, ECBC

DISCLAIMER: The findings presented in this briefing are not to be construed as an official Department of the Army position unless so designated by other authorizing documents.

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Outline

- Background
- Program overview
- “Virtual Prototyping” Use Cases
- Questions & discussion

Purpose

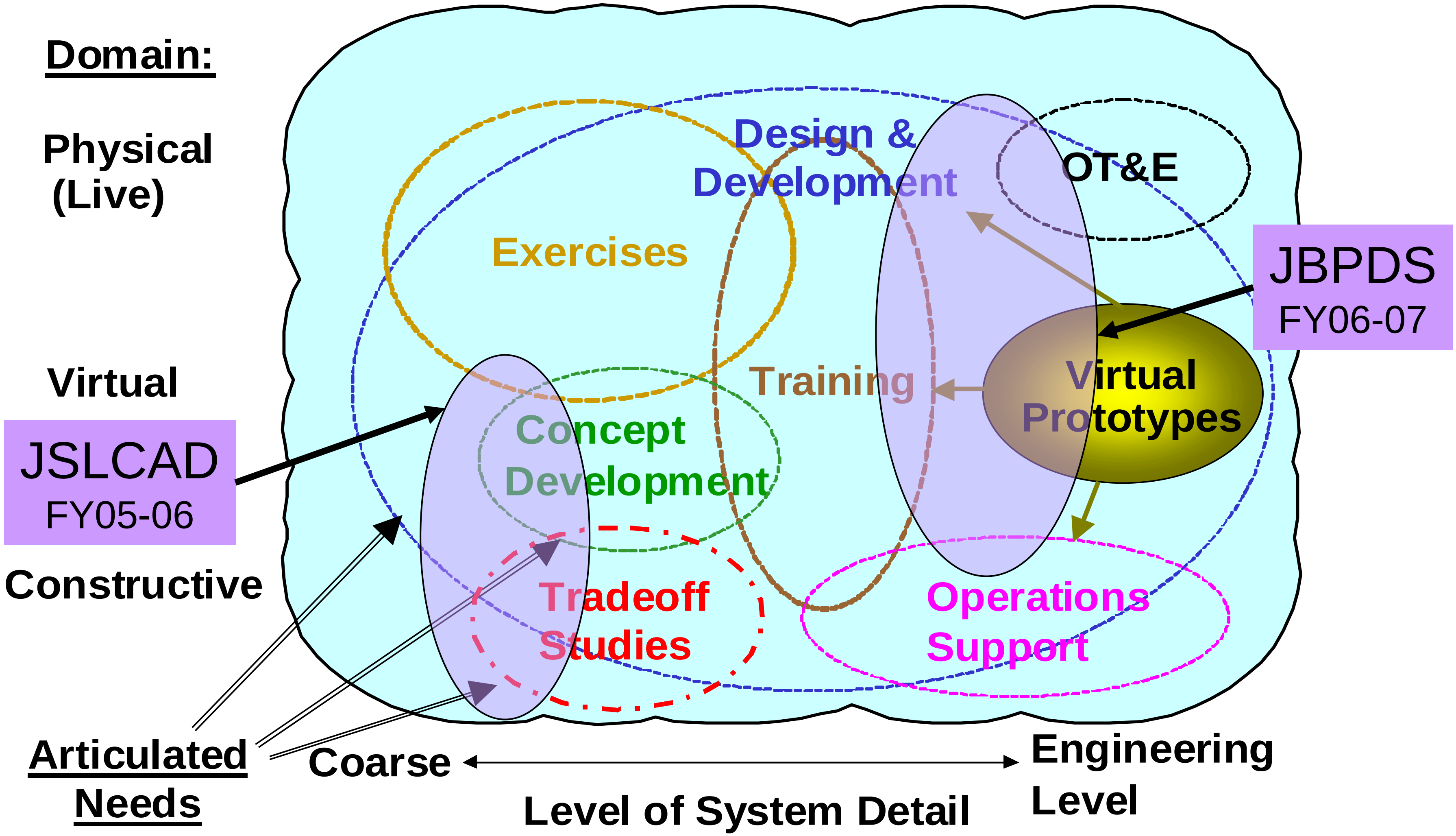
- To document the feasibility of virtual prototyping in support of select CBRN developmental programs and quantify the benefit of virtual prototyping to these developmental programs. Will provide lessons learned for application by other JPMs and identify virtual prototyping technology gaps that the JSTO program may desire to support.

"In the beginning…."

- Ancient history: The term "Virtual Prototyping System" harkens back to the days of Business Area Manager (BAM) Dave Grenier who had a vision to establish a one-stop shopping repository or environment of virtual prototyping tools that any JPM could walk up to and with some keystrokes ask it to help him/her design widget XXXX and, oh by the way, characterize its performance over a range of operating conditions. This initial attempt was met with everything from mild skepticism to utter hatred.

- DTRA CAPO requested analysis to answer issues raised in IDA Report, *Virtual Prototyping for the Chemical/Biological Defense Program*, October 2004

Domain for Use Cases

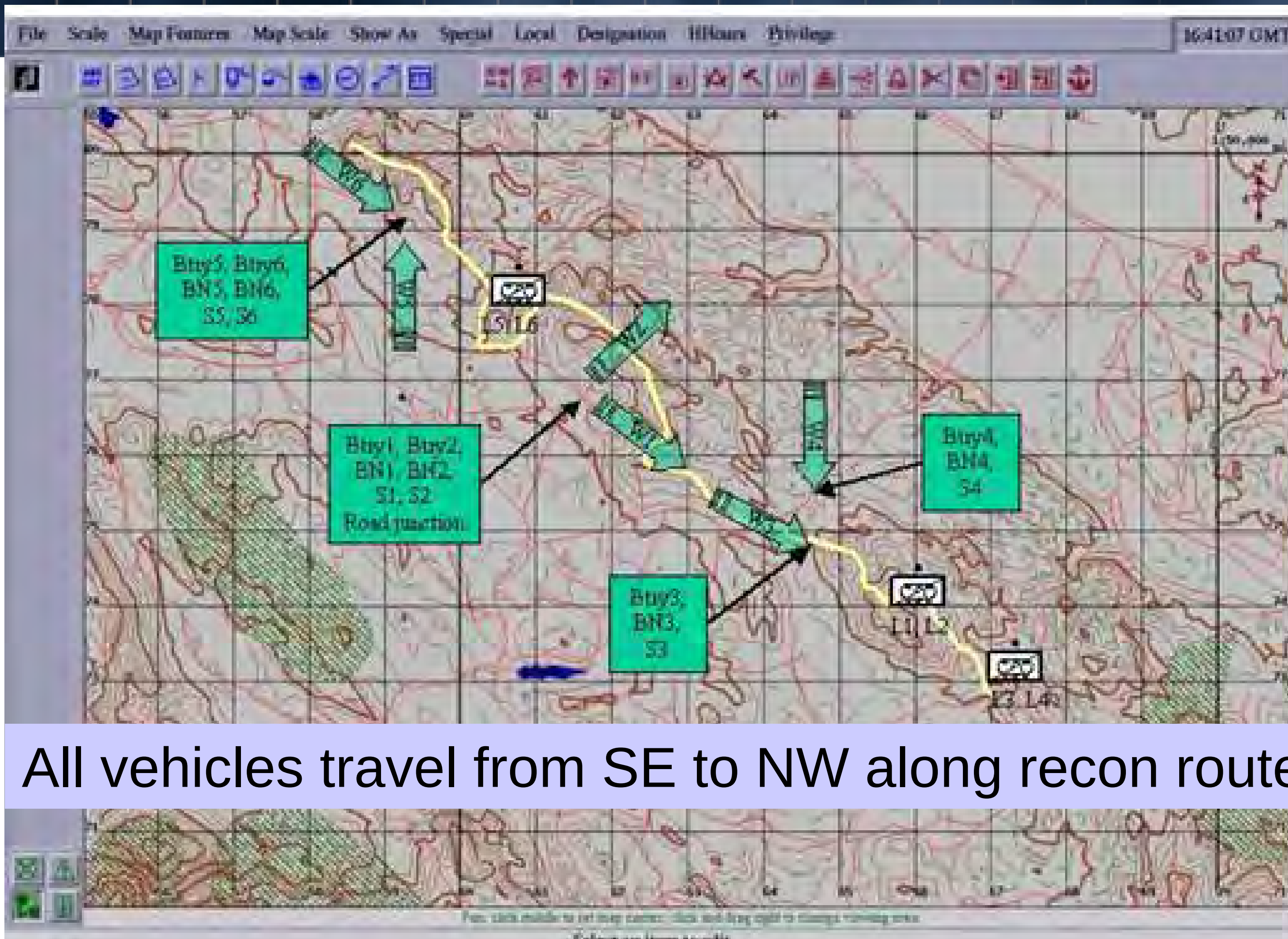


Functional Performance VP Use Case JSLCAD

- PM addressed the issue of elevation angle extents for system field of regard
- Needed to consider impact of terrain, attack type, vehicle route, etc.
- Tradeoff between large FOR to avoid missing an attack and smaller FOR to increase probability of detecting attack given it is within the FOR
- Using a variant of CB Dial-A-Sensor™ (CB DAS) called CB Analyzer which operates in non real-time mode

"Virtual Prototyping" Use case for System Performance Requirements

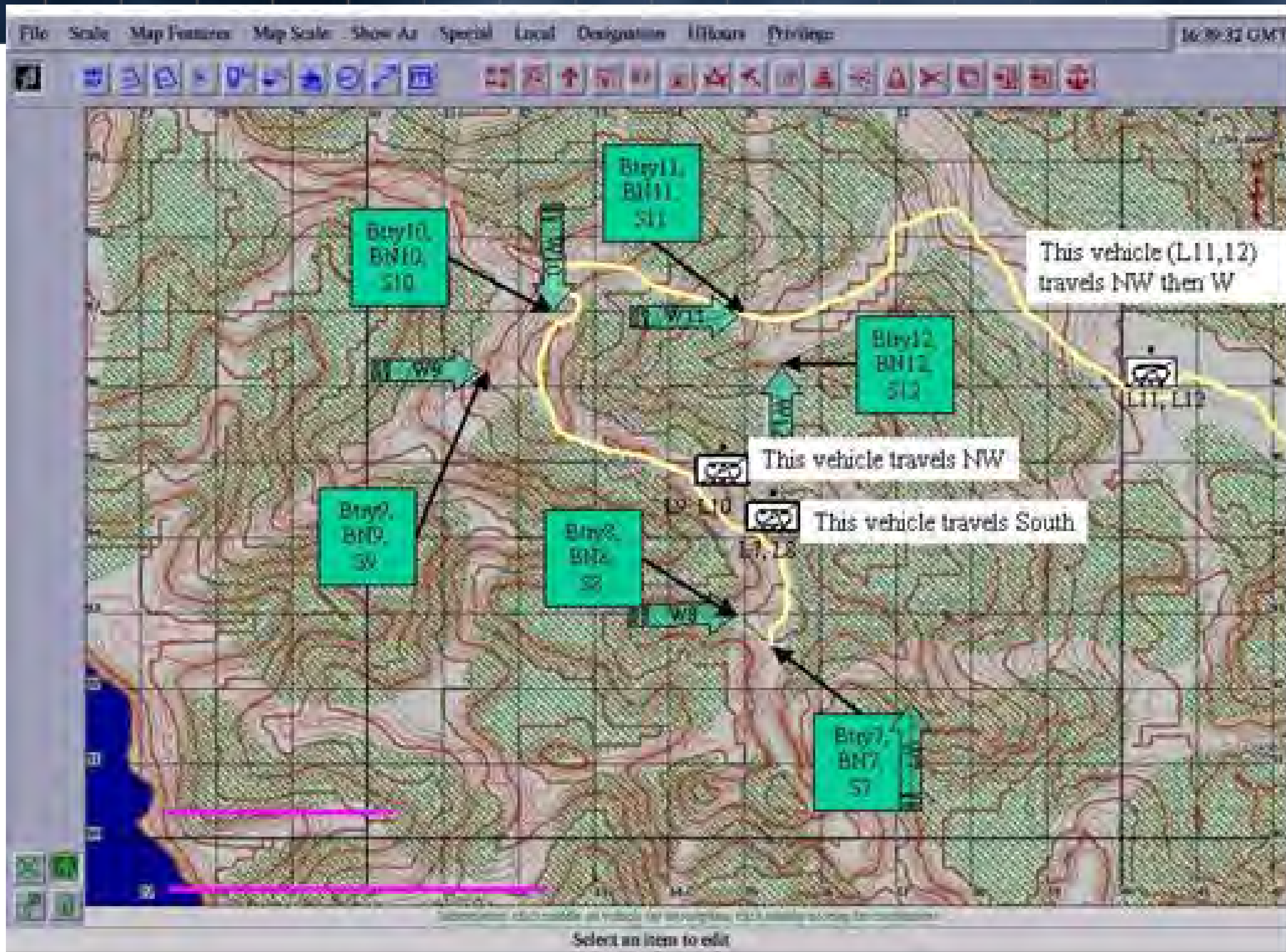
Operational Vignette
Moderate Elevation Terrain



All vehicles travel from SE to NW along recon route

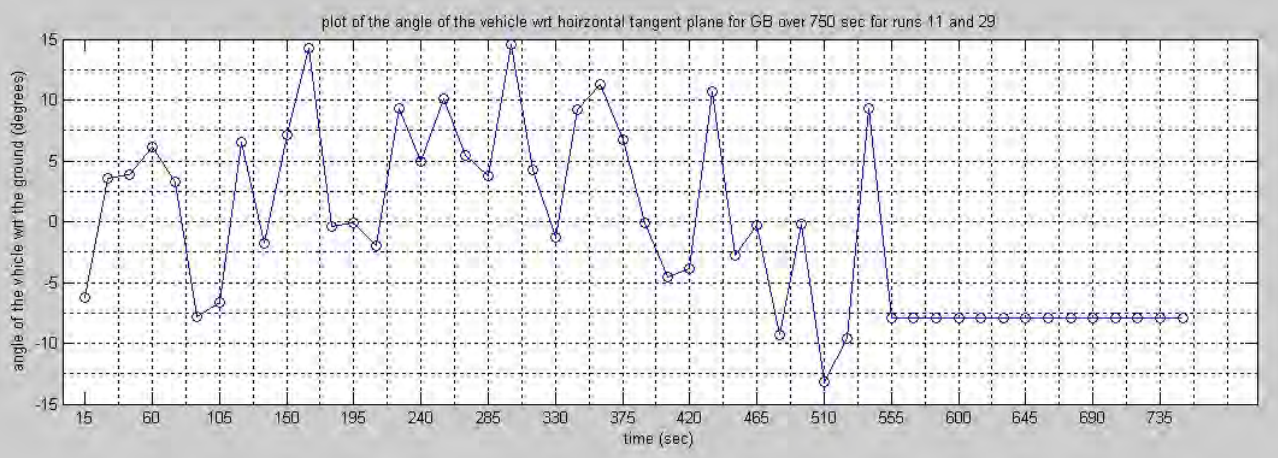
Extend system evaluation to conditions not currently tested

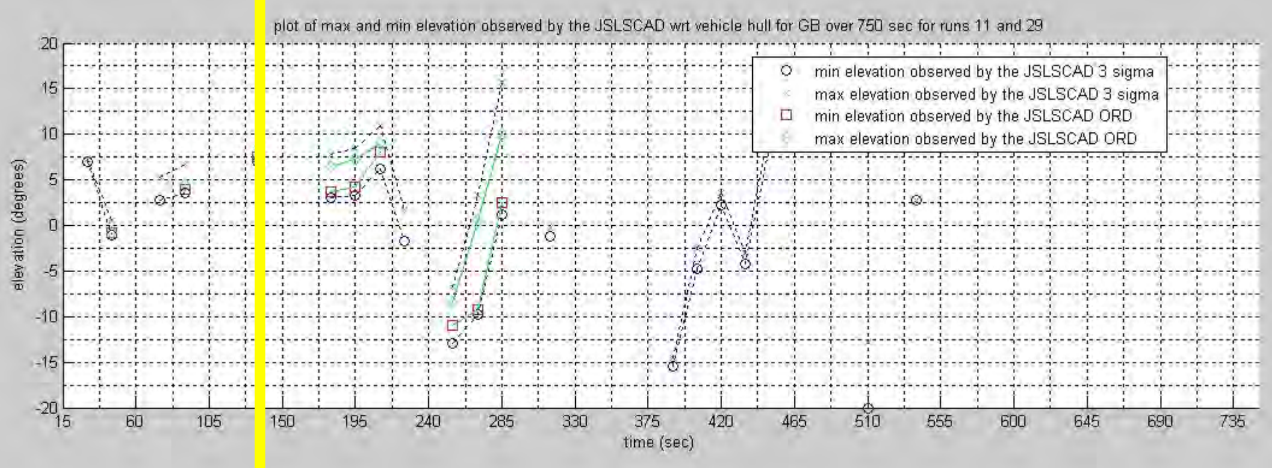
Operational Vignette
Mountainous Elevation Terrain



Extend system evaluation to conditions not currently tested

Use Case Example Results
(L5, W5, BN5)

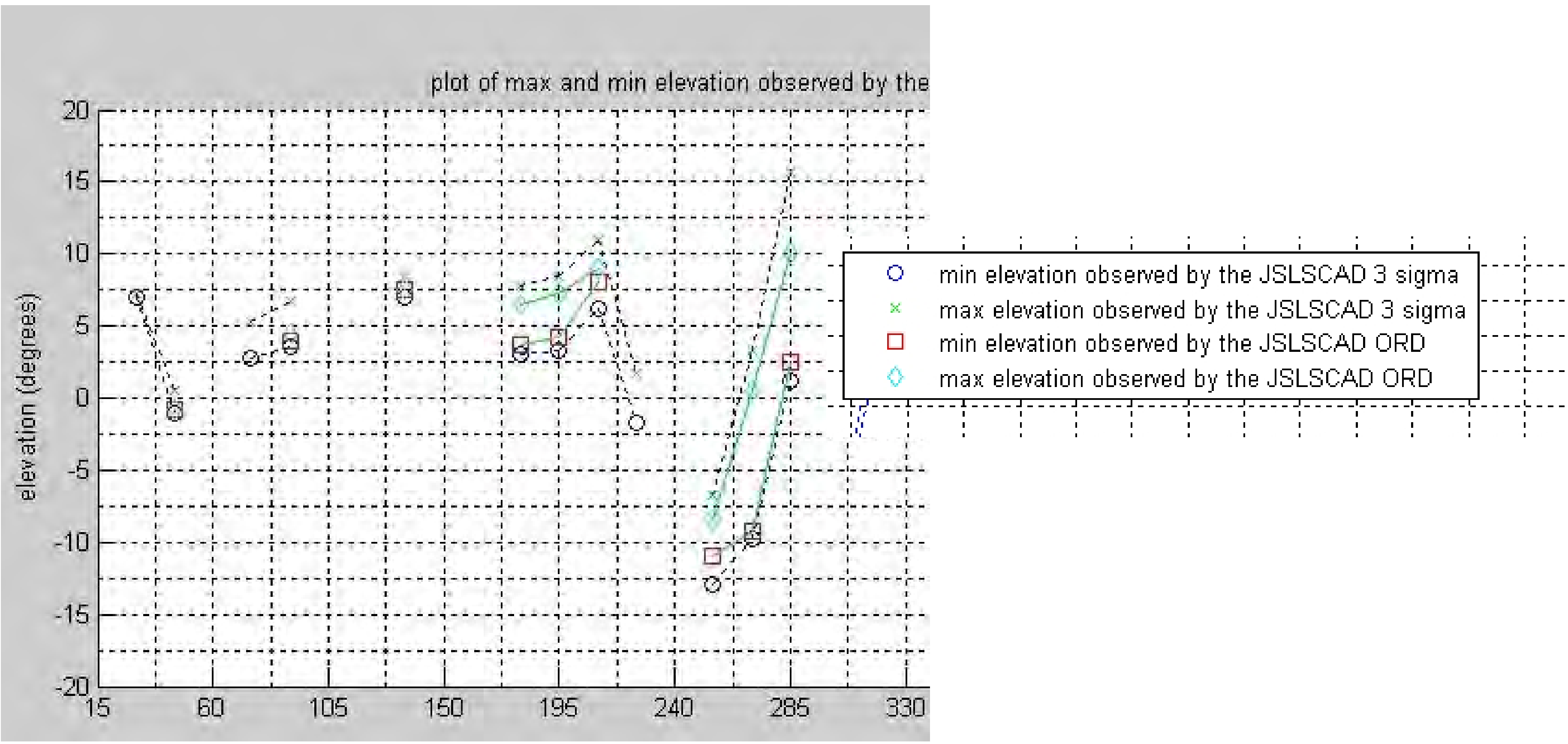




M&S Captures the Decidedly Dynamic Situation

Use Case Example Results

(L5, W5, BN5)



Windows of visibility

Functional Performance VP Use Case JSLCAD

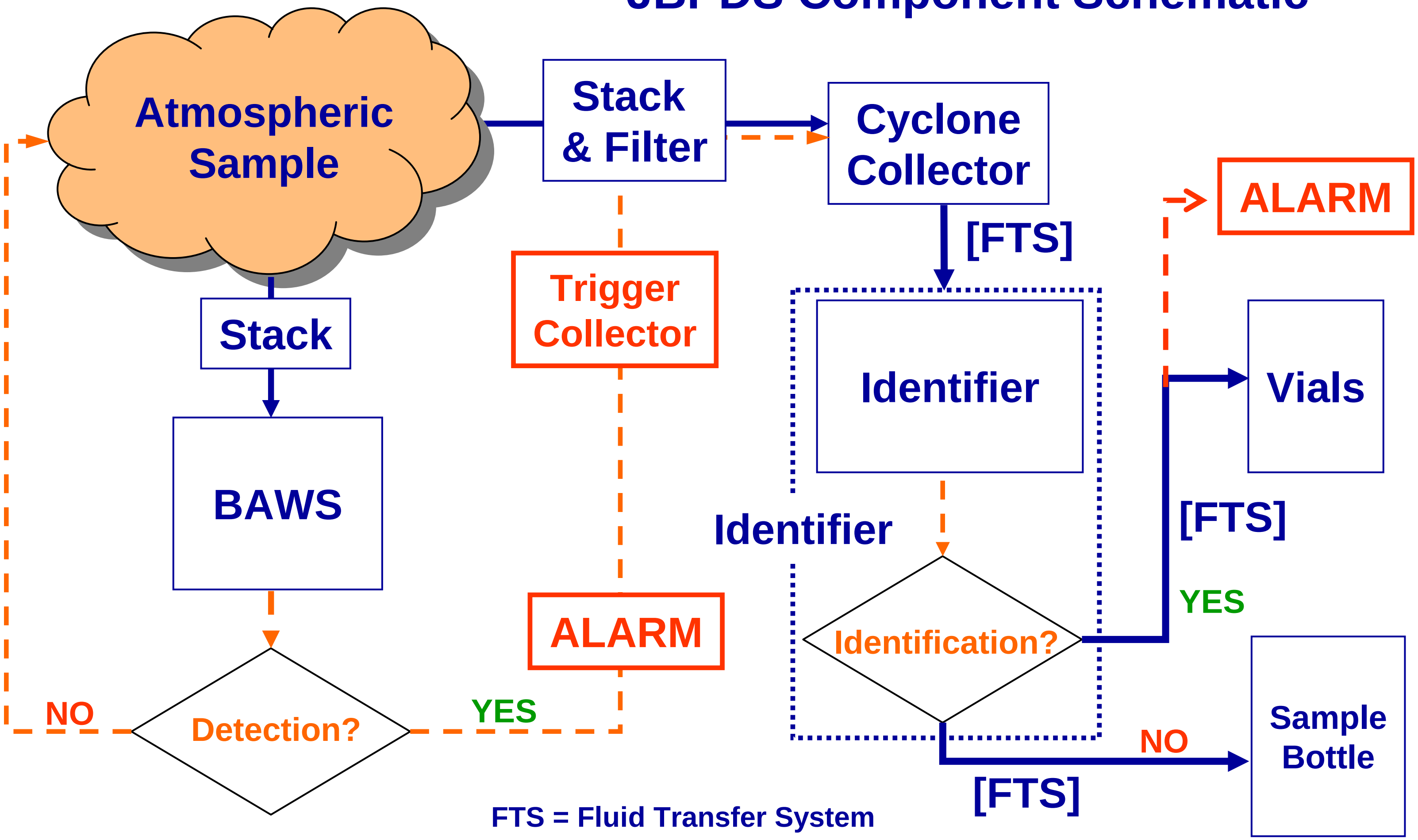
- The data from 288 simulation runs has been analyzed and the PM is considering next course of action.

- Same tools are also being used by Army Evaluation Center (AEC) and Dugway Proving Ground (DPG) to evaluate the effect of a reduced field of regard in both elevation and azimuth.

Others perceive this technique and these tools as useful

JBPDS System Modeling

JBPDS Component Schematic



FTS = Fluid Transfer System

True(er) Virtual Prototype In development for JBPDS System

JBPDS Modeling Goals

Support JBPDS Whole System Live Agent Test (WSLAT)

- Verification: “strung out” vs “as built”
- Extend test capabilities
- This effort was a recommendation of National Research Council (NRC) report

Establish a VV&Aed engineering level model to support future activities

- Operation in disparate environments
- Effects of system modifications

This demonstration will quantify how well they did

WSLAT V&V

- The modeling effort for WSLAT is wholly JPM funded. JSTO funds have been applied to the experimental design process for their V&V
  - MSA Team, has provided experimental design support for most aspects of the chamber and field testing.
- The WSLAT team has involved the test and evaluation community from the get go
- This will be a good test of how far the VV&A process can be pushed to allow M&S to focus/extend/supplant traditional testing

PM Perceptions

- Using VP to clarify/refine performance requirements translates to cost savings due to avoiding redesign
- PMs see need as they are funding on their own; however…
- A common VPS or toolbox *could* lead to better reuse of code and the ability to apply virtual prototyping earlier in the development process
  - Issue may be as much cultural and programmatic as opposed to technical
  - However, recent developments within JPOE CBD are revitalizing idea of common (possibly reusable) M&S and analytical techniques across the JPMs
- Final quantification of benefit depends on:
  - Ability to perform and document VV&A
  - Acceptance by T&E community: if M&S does nothing to reduce or focus testing, what doth the PM gaineth?
  - Success or failure of PM to get performance requirements modified based on M&S results

Benefit Quantification Ongoing

VPS report schedule

- Both use cases documented with additional findings in FY07 final report
- Mar 07: Draft for review by TAM and others at her direction. Will include all JSLCAD outcomes and lessons learned. For JBPDS this version will likely not have much on the V&V since full scale testing will still be ongoing.
- Apr-May 07: Receive input and revise report
- Jun 07: Final report published

Agent Fate Predictive Modeling

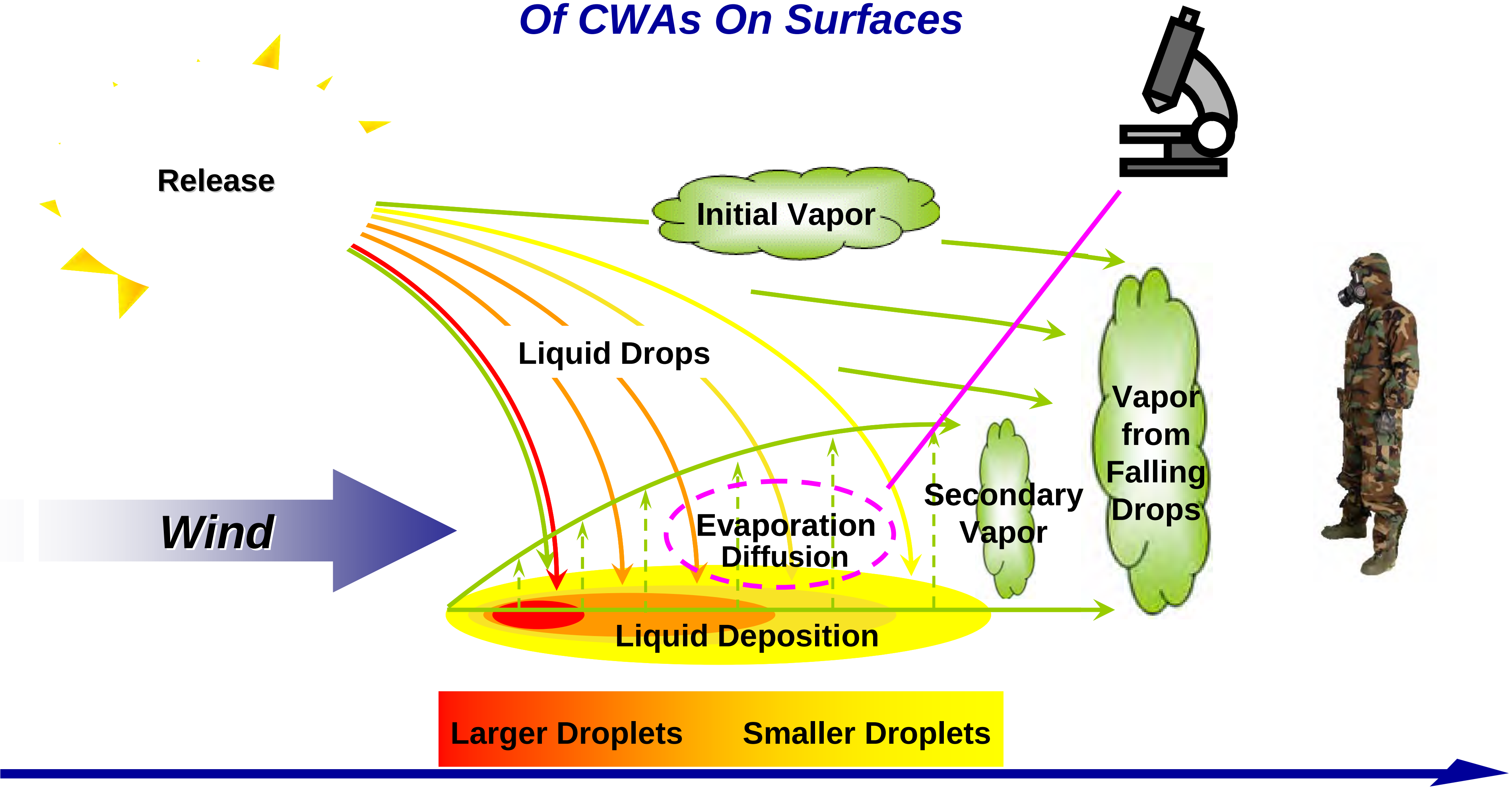
William Kilpatrick
Air Force Research Laboratory
Wright-Patterson AFB, OH

Overview

- What Is Agent Fate?
- History of Agent Fate Modeling
- Agent Fate DTO Predictive Modeling
- Post-DTO Agent Fate Modeling
- Transitioning Agent Fate Modeling S&T
- Summary

What Is Agent Fate?

Measuring and Predicting The Physico-Chemical Processes Of CWAs On Surfaces



History of Agent Fate Modeling

- Sutton (1933) - PR 1102
  - 1st theoretical investigation in light of turbulence theory (i.e., wind velocity & temperature gradients) on smooth surfaces
- Pasquill (1942) – PR 2335
  - First indepth treatment of aerodynamic effect on evaporation
  - Introduced molecular diffusivity in lieu of air viscosity in Sutton's model to describe vapor transport based on momentum exchange
- Calder (1947) – PTP33
  - Theoretical treatment on problem of eddy diffusion and evaporation
  - Used lab data to establish laws of turbulent flow
- Monaghan & McPherson (1971) – STP 386
  - 2-D atmospheric diffusion model calibrated to Canadian Prairie Grass
- NUSSE (1979)
  - Used STP 386 prairie grass methodology with correction factors for sand and HD

History of Agent Fate Modeling

- Chinn (1981)
  - Empirical model based on volatility, drop size, wind velocity, & agent purity
- D2PUFF/D2PC (1987) [DoD model for industrial chemical hazards]
  - 2-D atmospheric diffusion model with semi-empirical correction for transition to rough surfaces
  - Used in CSEPP
- VLSTRACK (1992) [DoD model for passive defense applications]
  - Engineering evaporation model for mass transfer (i.e., non-dimensional parameters)
  - Key evaporation parameters calibrated to evaporation data (surface evaporation, absorption rate, desorption rate)
- Roberts (1994) [Integrated into HPAC version 4.0]
  - Physics model of evaporation from sand and concrete surfaces
- SCIPUFF/HPAC (1996) [DoD model for counter-force applications]
  - Lagrangian transport and diffusion model; turbulence diffusion based on second-order closure theory

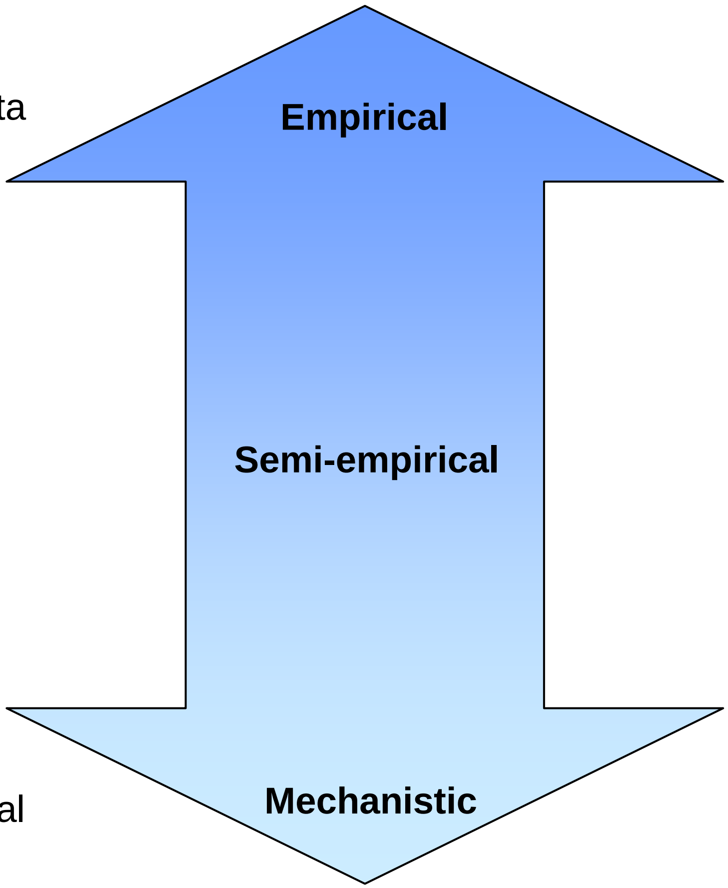
History of Agent Fate Modeling Lessons Learned

- Mix of empirical and physics-based modeling
- Similar physics (2-D diffusion, dimensionless mass and energy parameters)
- Porous substrate modeling empirically driven or simple physical representations
- No explicit agent-surface interaction chemistry
- *Model accuracy, fidelity, and confidence limited by empirical data*

Agent Fate DTO Modeling

Model Development Is Data Intensive Activity

Fit To Data



Theoretical

Key Features

- Numerically Efficient
- Limited To Available Data
- No Physical Representation
- Requires Response Data
- Excellent Prediction

- Numerically Inefficient
- Extensible Beyond Data Space
- Physical Representation
- Requires Response and Physical Parameter Data

Examples

Chinn

Pasquill

Roberts

VLSTRACK

STP 386

Empirical Model

Fit To Response Variable

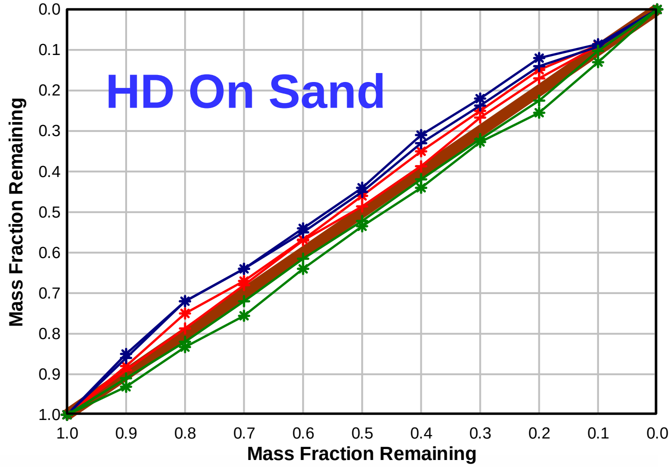
Model Output: Agent fraction remaining over time

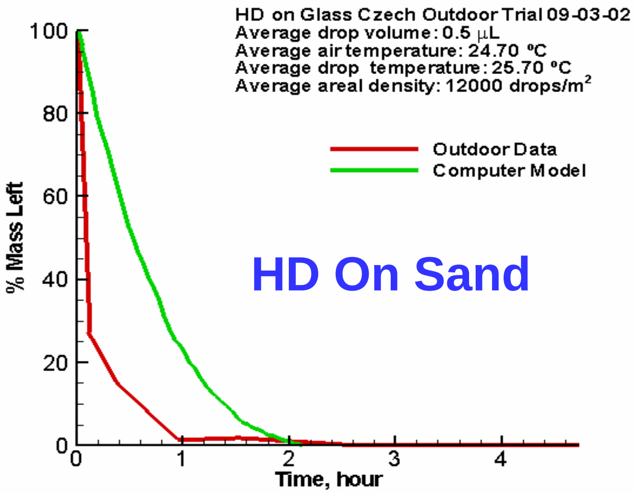
Model Inputs: Ground temperature, droplet, size, wind speed, humidity

Model Type: Exponential decay function

Model Data: Agent fraction remaining, droplet, size, wind speed, humidity, agent substrate

Experimental Method: Wind tunnel, end extraction validation to open air trials





Theoretical Model

Modeling of Fundamental Physico-Chemical Mechanisms

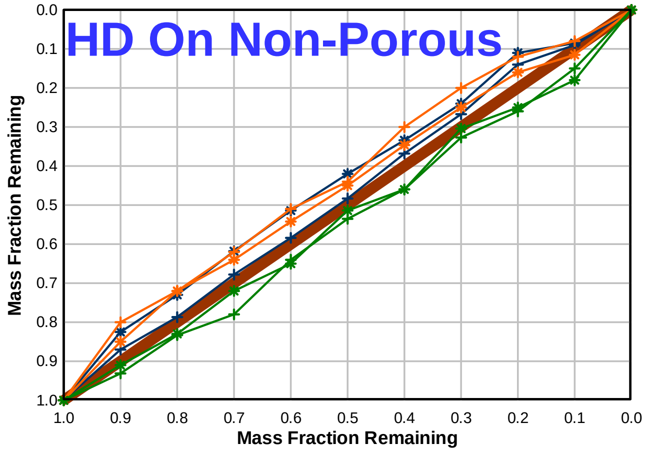
Model Output: Agent fraction remaining over time

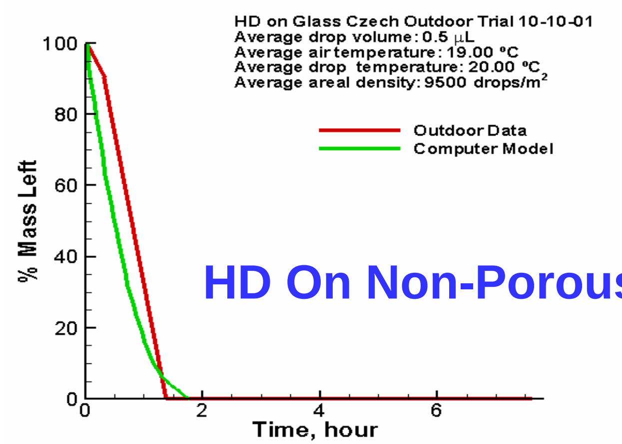
Model Inputs: Re, Sc, Pr, u*, height of drop, wetted area radius, contact angle, air viscosity, drop & air temperature, saturation, permeability, relative permeability, diffusion coefficient, capillary pressure, porosity, surface tension, chemical interaction params

Model Type: Engineering model

Model Data: Agent fraction remaining, droplet, size, wind speed, humidity, agent substrate, permeability data, initial wetted area size, diffusion coefficients, agent reaction data

Experimental Method: Wind tunnel, end extraction, various lab experiments, reaction kinetics, open air field trials for model validation



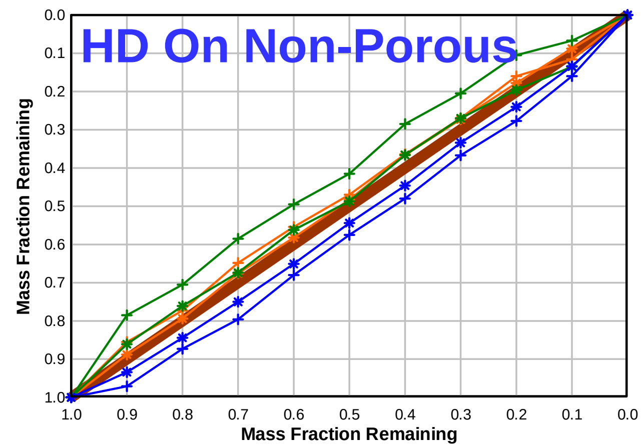


Semi-Empirical Model

Physics-Based Model With Empirical Fitting

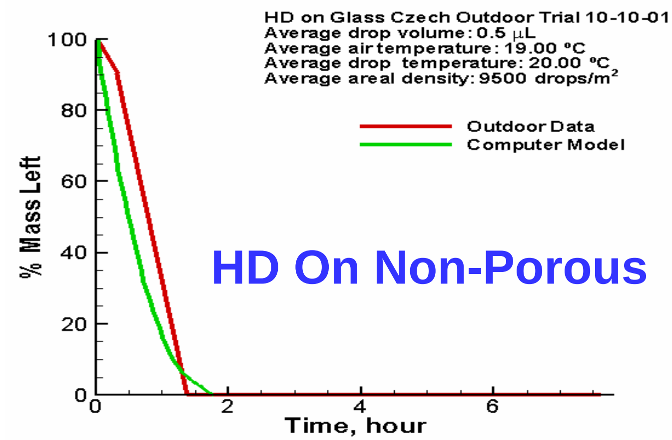
Model Output: Agent fraction remaining over time

Model Inputs: Ground temperature, droplet, size, wind speed, humidity, agent properties, diffusion layer thickness, initial contact angle, plug initial surface radius and depth, pore fill fraction, transition point from liquid to vapor transport phase, activation energies, reaction kinetics, order of reactions, impurities & their diffusivity & volatility



Model Type: Diffusion-based physics model

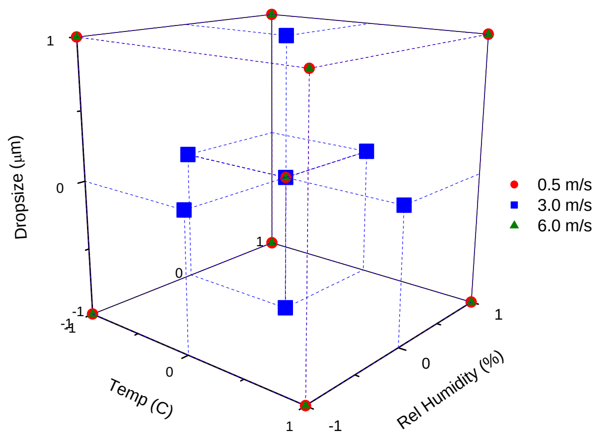
Model Data: Agent fraction remaining, droplet, size, wind speed, humidity, agent substrate, agent reaction data



Experimental Method: Wind tunnel, end extraction, various lab experiments, reaction kinetics, open air field trials for model validation

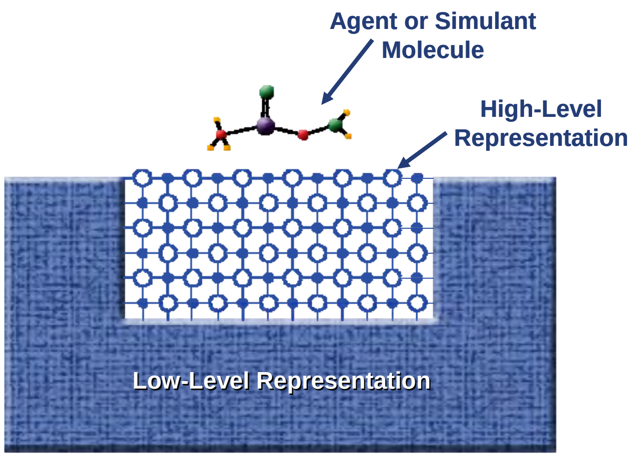
Future of Agent Fate Modeling

Factorial Experimentation (Historical Approach)



- Too many permutations
- Limited/no use of agents in the field
- Risk & cost associated with any agent work
- Rate of emerging threats overcomes ability to generate data in a timely manner

Model Agent/Material Interaction (Future Approach)

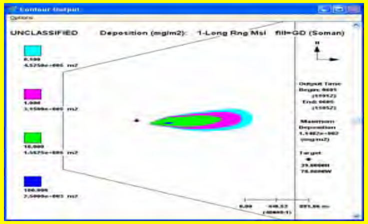


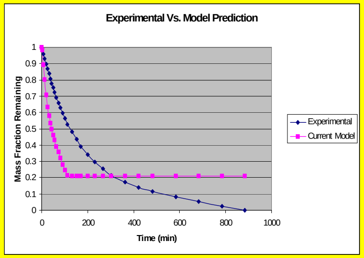
- Computational chemistry & physical modeling
- Reduces dependence on large quantity of agent-material experiments
- Better focuses experimental requirements
- Greater use of simulants to validate key physico-chemical processes

Future of Agent Fate Modeling

- Pro’s
  - Reduce live agent experimental requirement
  - Greater use of simulants
  - Independent of threat agent or material
  - More responsive to growing need of threat agent data
- Con’s
  - Multiple experiments replace single response surface experiment
  - New experimental methods need to be designed
  - Still require some live agent factorial testing to validate models and key processes

Maintain Transition Focus



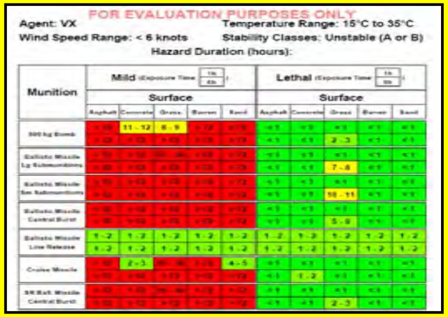


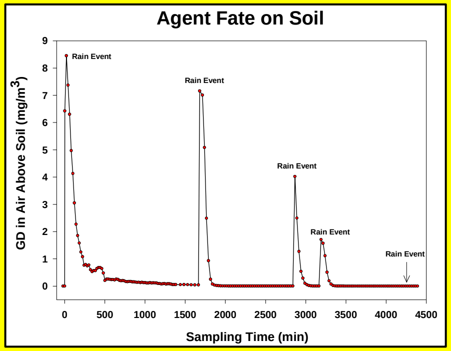
Acquisition Support

Decision Aids

CONOPS TTP

S&T Community





Summary

- Lessons learned provided modeling starting point
- DTO covered full spectrum of agent fate modeling
- Traditional experimental approach too unwieldy for growing need of agent fate data
- Greater emphasis on computational modeling holds promise to be more responsive and less costly
- S&T community becomes a prime user for future agent fate modeling technology

UNCLASSIFIED

A Practical Method for Calibration of Ensemble Spread for Representation of Meteorological Uncertainty in Atmospheric Transport and Dispersion Models

Walter Kolczynski, Jr.

Dave Stauffer

Sue Ellen Haupt

Chemical and Biological Information Systems Conference & Exhibition
11 January 2007
Austin, TX

PENNSTATE

1855

Overview

- Goals
- Motivation
- Methodology
- Linear Variance Calibration (UUE,VVE,UVE)
- Linear Covariance Calibration
- Covariance/Distance Relation (SLE)
- Conclusions
- Future Work

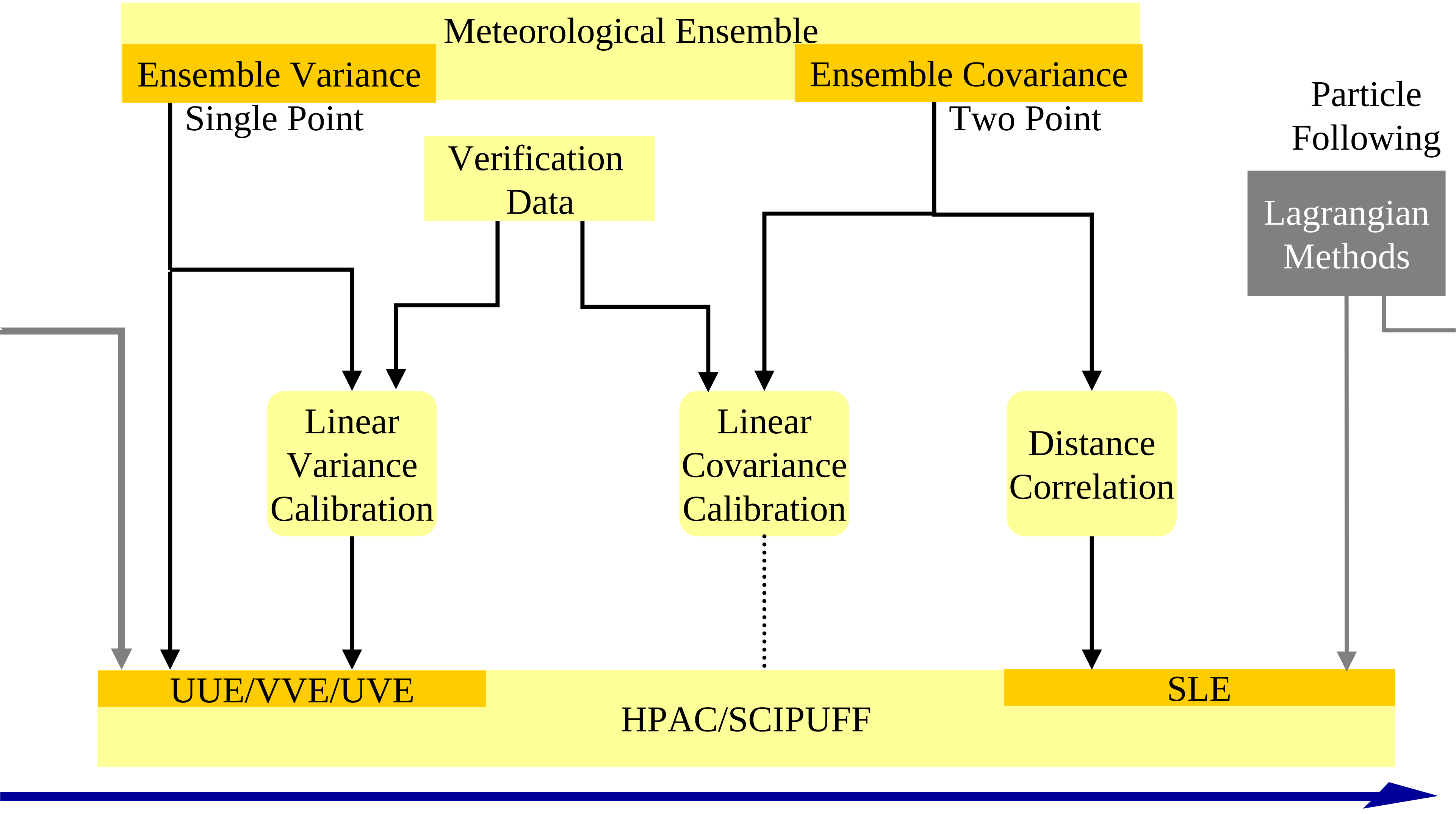
Goals

- Use an ensemble of MET models to provide HPAC/SCIPUFF with MET uncertainty information to account for uncertainty in AT&D computations
- Study applicability of a new efficient linear calibration method to compute these MET uncertainty inputs to HPAC/SCIPUFF

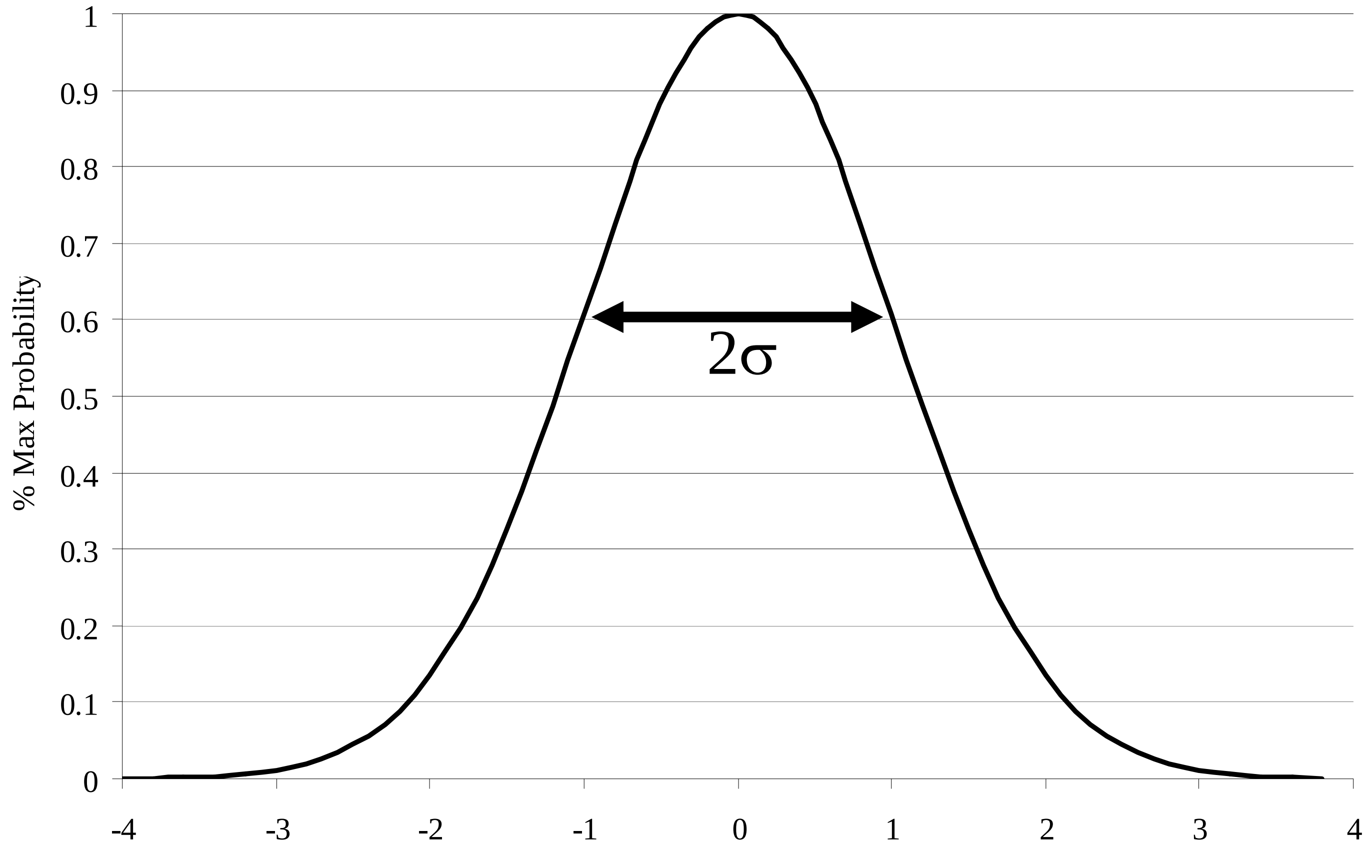
Motivation

- The variability and correlation of MET errors have important implications to AT&D predictions
- MET uncertainty information can already be input to SCIPUFF through wind variance matrices (UUE, VVE, UVE) and the Lagrangian length scale (SLE)
- Running an ensemble of AT&D models based on the MET ensemble to represent the uncertainty may not be practical for operations
- When an ensemble of AT&D models is not possible, an efficient way to pass MET uncertainty information from the MET ensemble into the single AT&D model solution is needed

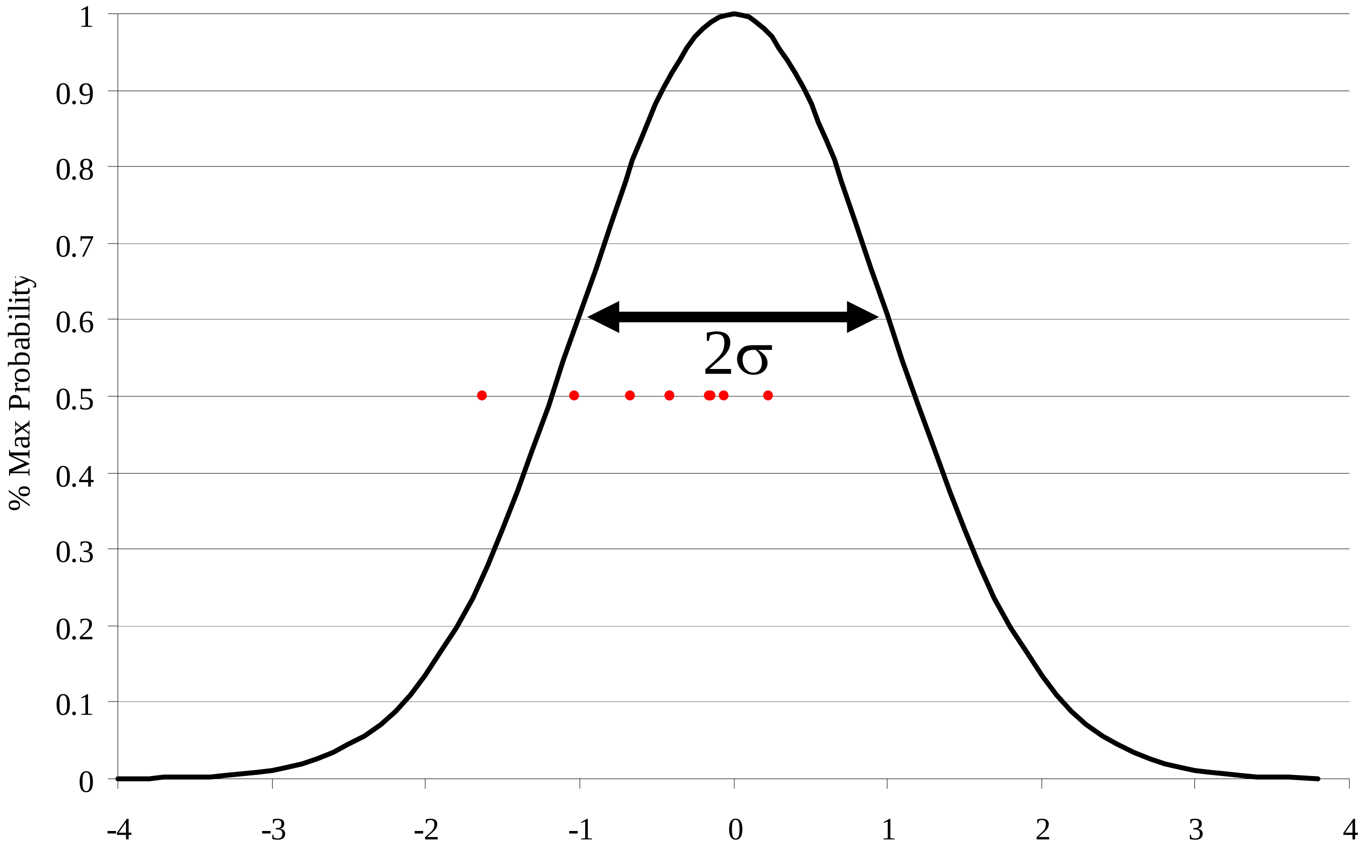
Uncertainty Information Pathways



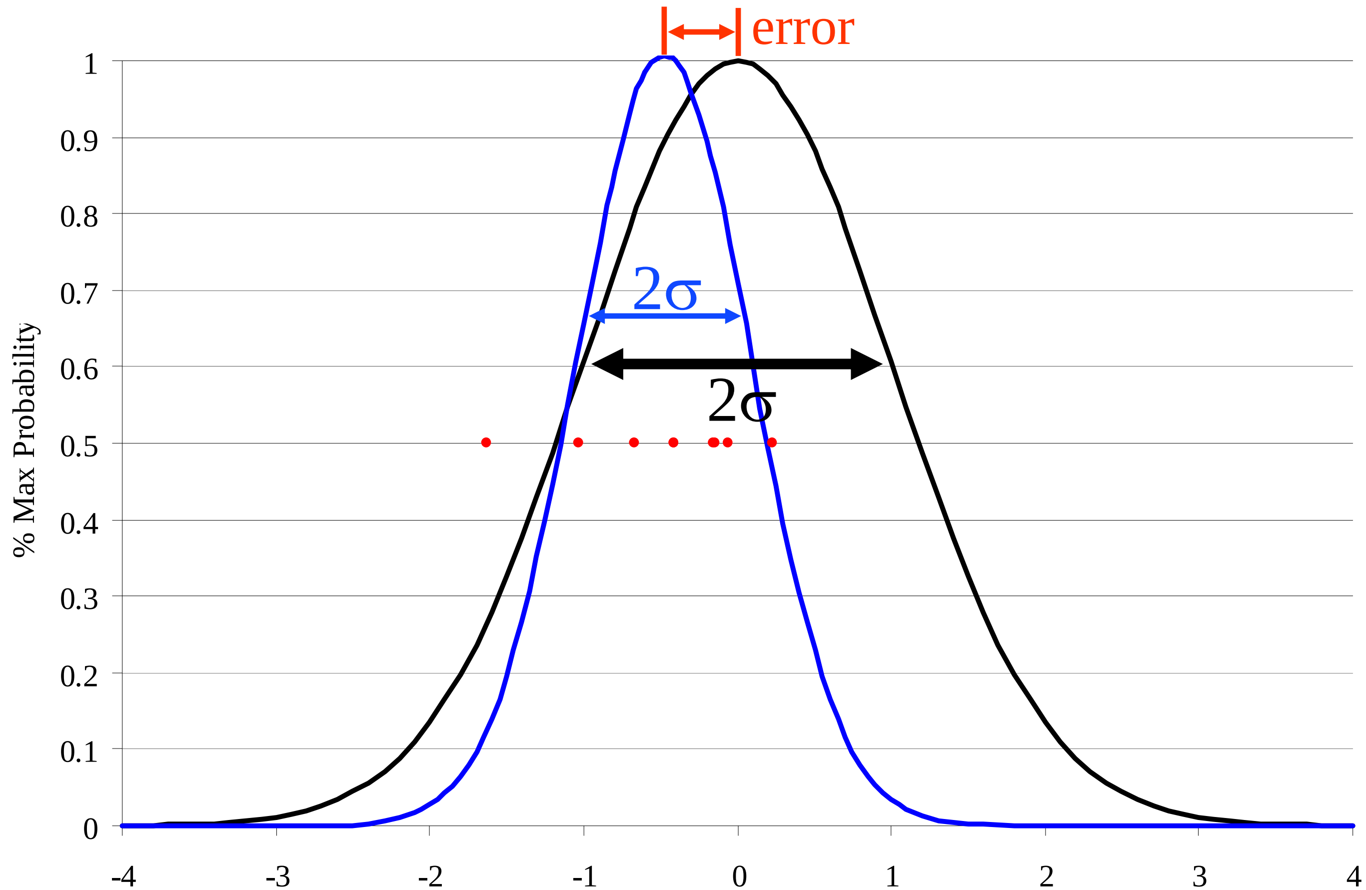
Motivation



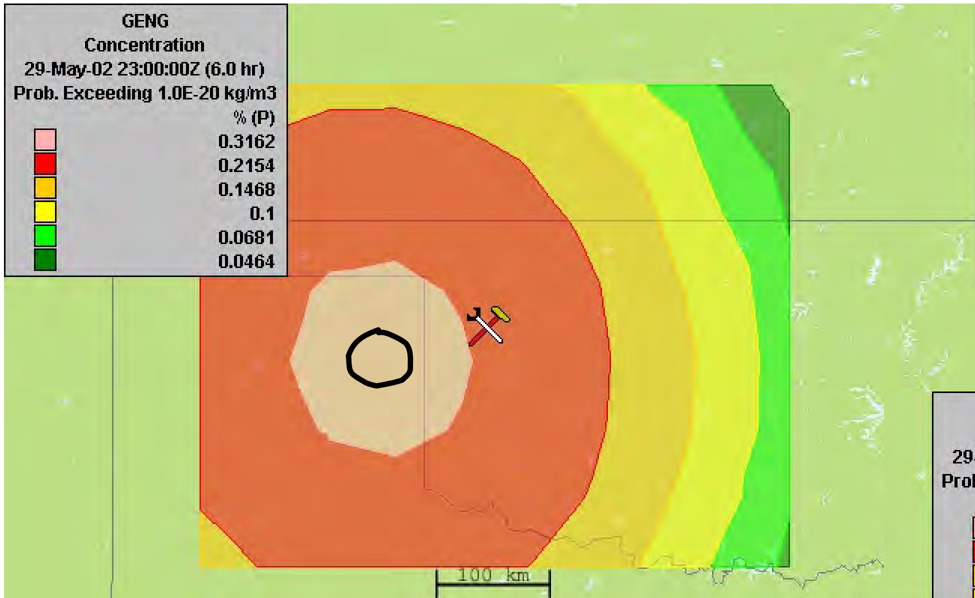
Motivation



Motivation

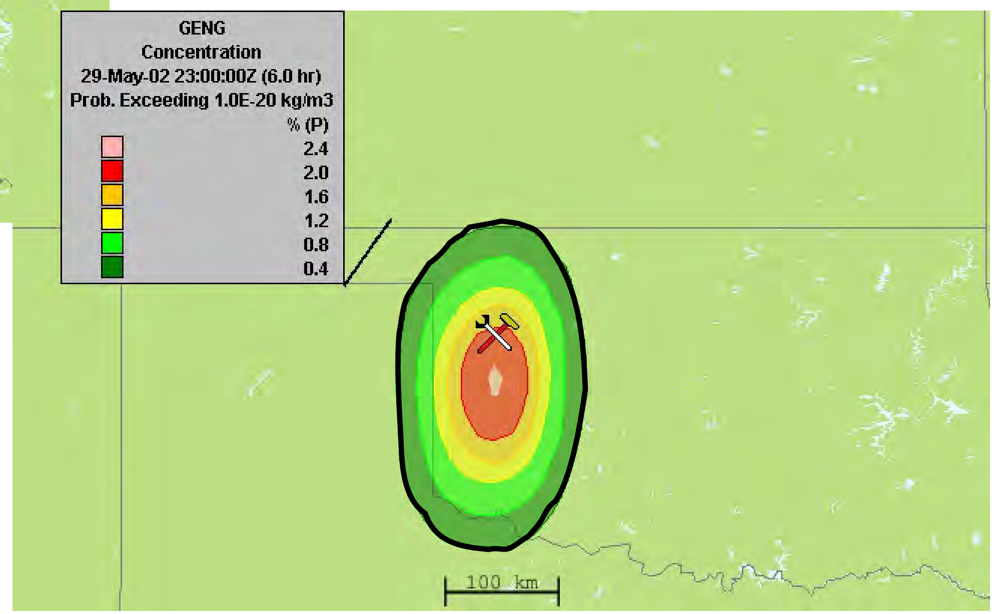

error
2σ
2σ
% Max Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-4
-3
-2
-1
0
1
2
3
4

Motivation



UUE = 100 m^2/s^2

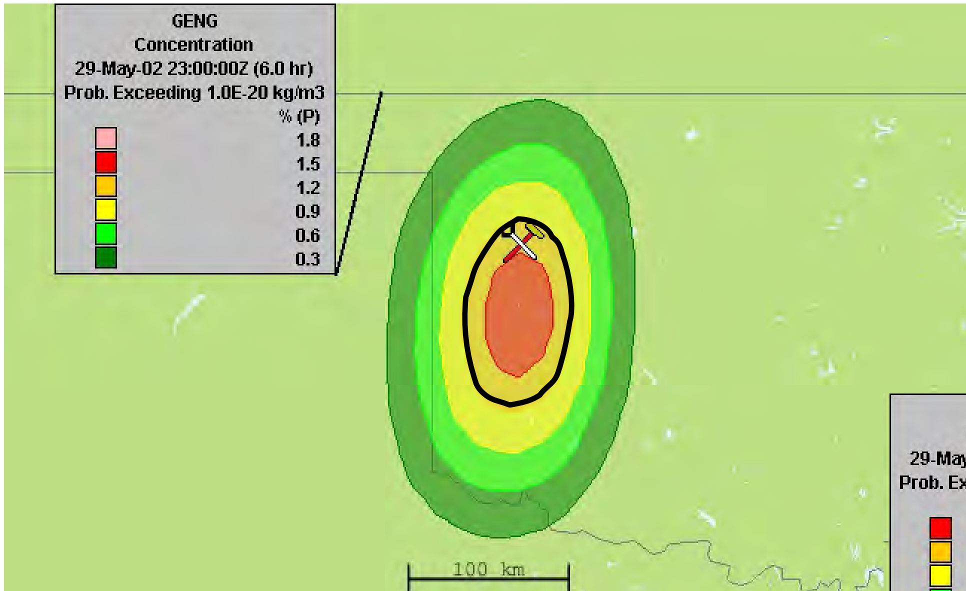
Constant SLE = 109 km



Probability of concentration Greater than 10^{-20} kg/m^3

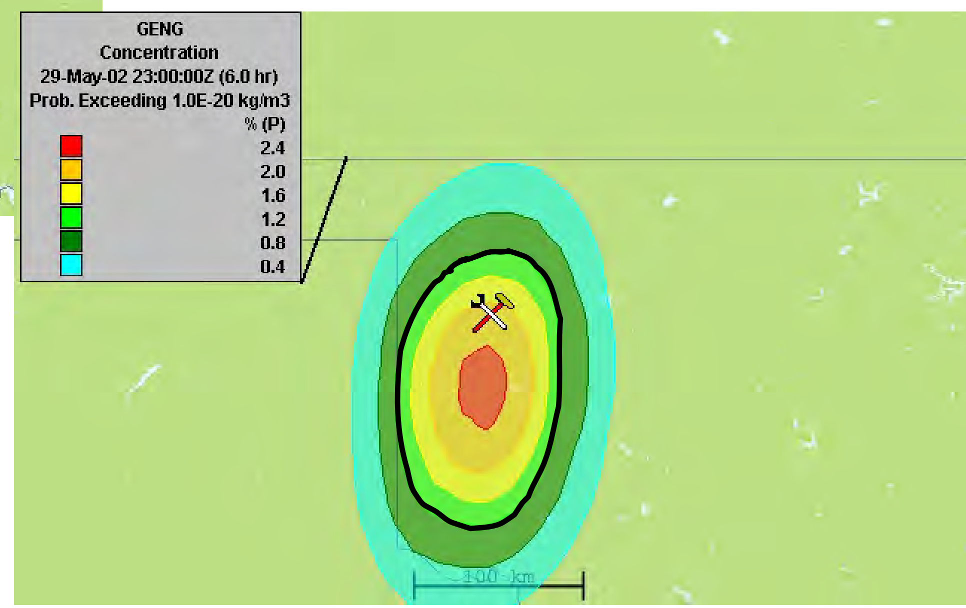
UUE = 1 m^2/s^2

Motivation



SLE = 27 km

Constant UUE = 0.4 m^2/s^2



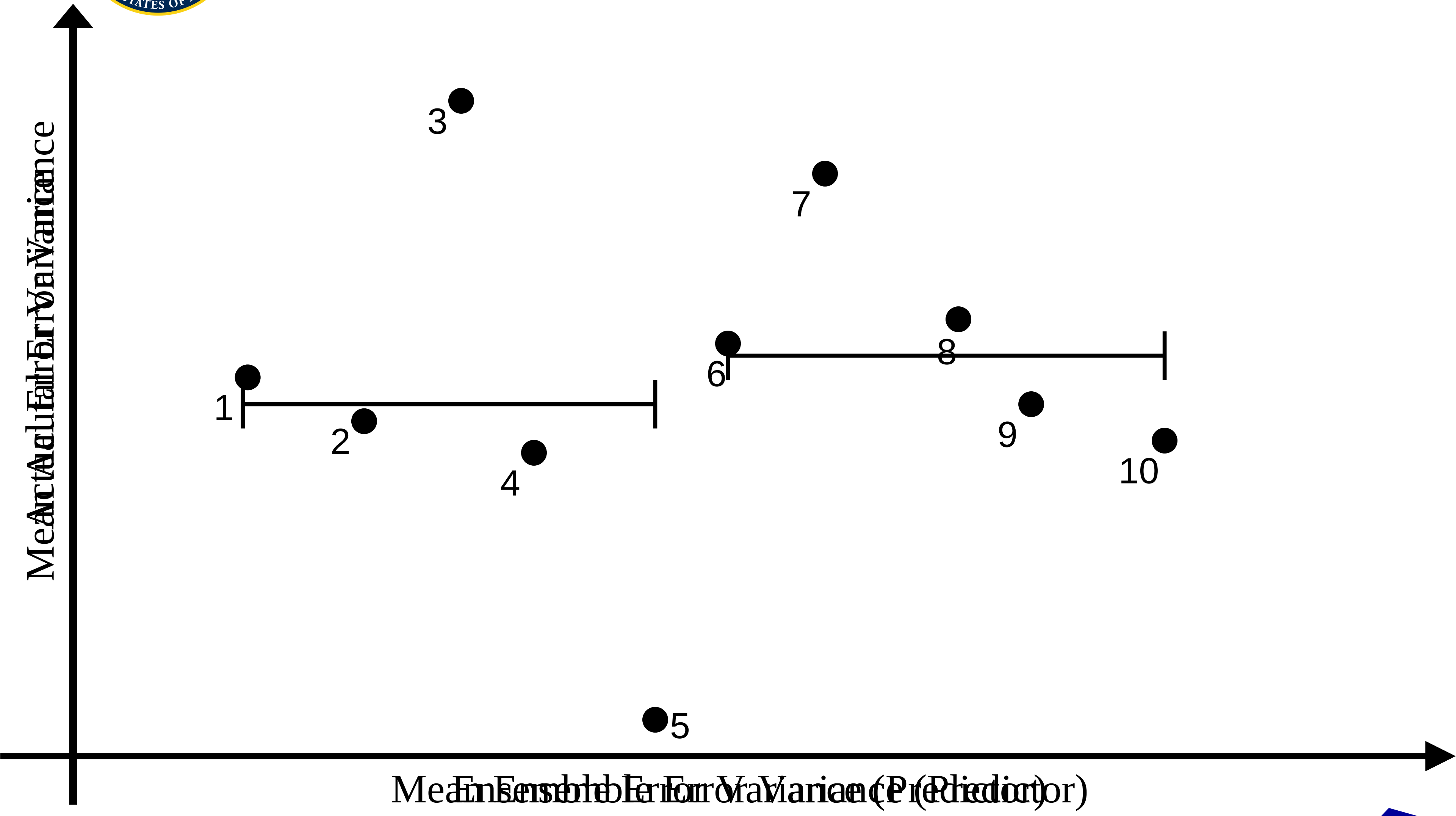
Probability of concentration Greater than 10^{-20} kg/m^3

SLE = 164 km

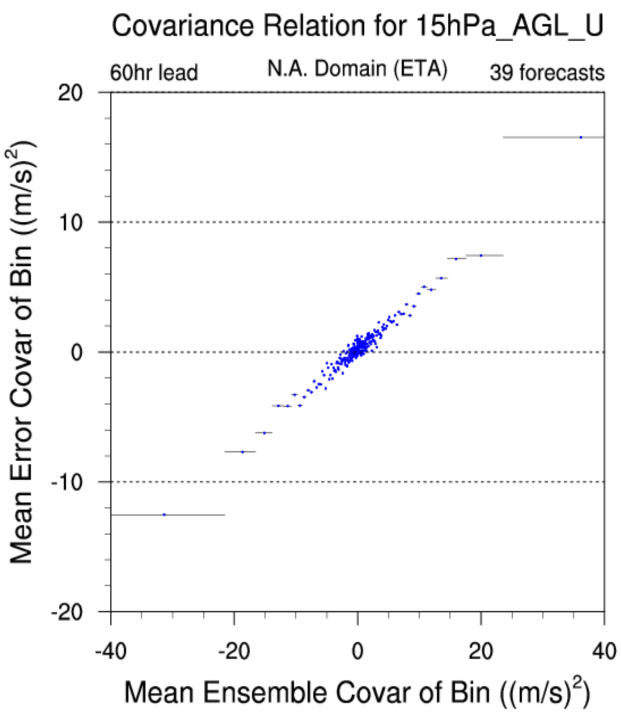
Methodology

- Use bootstrap sampling
- Bin results based on the predictor value, following Roulston (2005)
- Analyze plots for a simple relationship (linear) to be used as a calibration to ensemble data
- Utilize existing available ensemble data (SREF-ETA) to assess the promise of the technique

Methodology – Binning Procedure



Methodology – Binning Procedure



Points binned into groups of 1000

Methodology – SREF Ensemble Data

- 25 August to 15 September 2004 (22 days, 44 ensemble sets)
- Two runs per day (09 UTC and 21UTC)
- Forecasts for 12, 24, 36, 48 and 60 hrs considered
- 10 ETA members (32-km resolution)
- 0-hr forecast of ETA-ctl1 used as verification
- U and V winds “15 hPa AGL” (~150 m) used

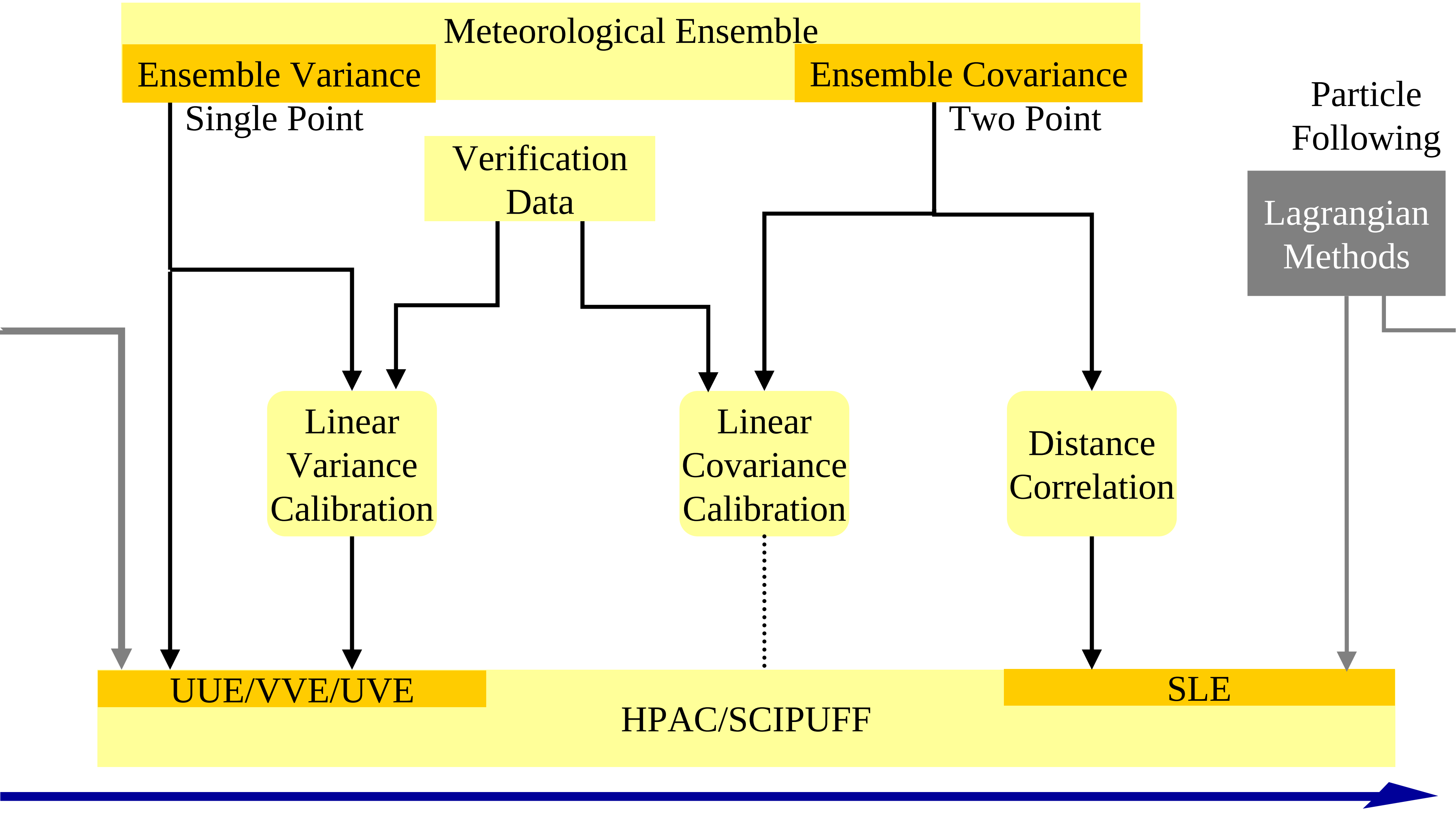
Methodology – SREF ETA Members

Case Name	Convection	Microphysics	Breeding IC
Eta_ctl1	BMJ	OpFer	-
Eta_ctl2	KF	OpFer	-
Eta_n1	BMJ	OpFer	Eta_ctl1
Eta_n2	KF	OpFer	Eta_ctl2
Eta_n3	BMJ-SAT	OpFer	Eta_ctl1
Eta_n4	KF-DET	ExFer	Eta_ctl2
Eta_p1	BMJ	OpFer	Eta_ctl1
Eta_p2	KF	OpFer	Eta_ctl2
Eta_p3	BMJ-SAT	OpFer	Eta_ctl1
Eta_p4	KF-DET	ExFer	Eta_ctl2

BMJ: Betts-Miller-Janic KF: Kain-Fritsch SAT: Sat. Profile DET: Full Detrainment

OpFer: Operational Ferrier Micro ExFer: Experimental Ferrier Micro

Linear Variance Calibration



Linear Variance Calibration

$$EVar\left(s(ij)\right) = \frac{1}{N}\sum_{m=1}^{N}\left(s_m(ij) - \overline{s(ij)}\right)^2$$

$$AVar\left(s(ij)\right) = \left(s_v(ij) - \overline{s(ij)}\right)^2$$

$s(ij)$ is the value of a scalar field at point (i,j)

$EVar\left(s(ij)\right)$ is the Ensemble Variance of s at point (i,j)

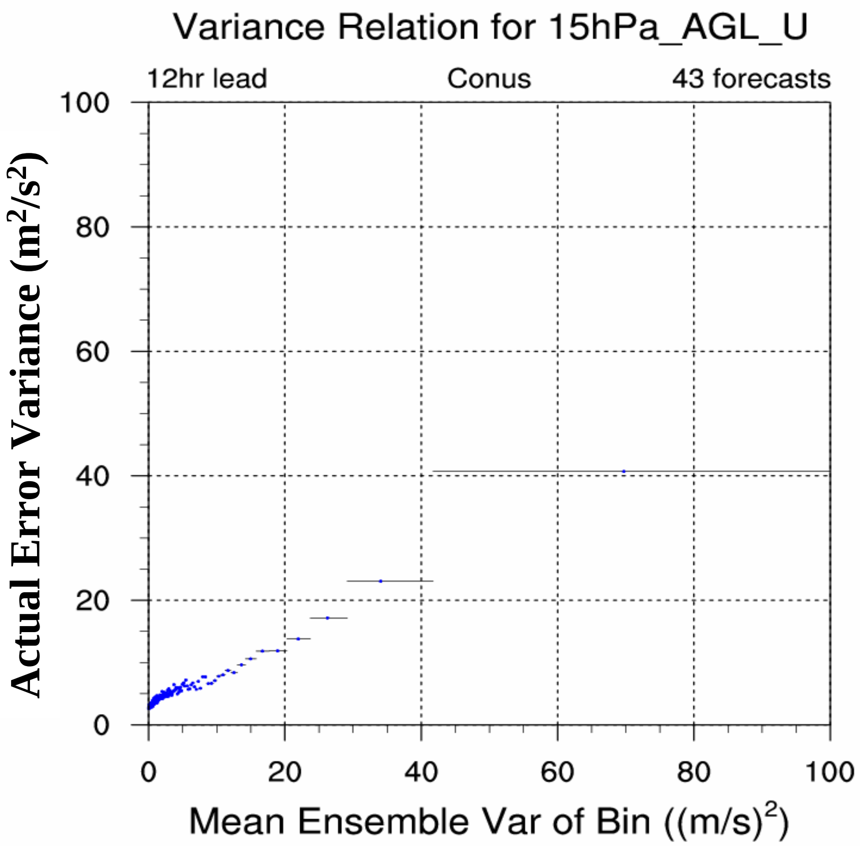
$AVar\left(s(ij)\right)$ is the Actual Variance of s at point (i,j)

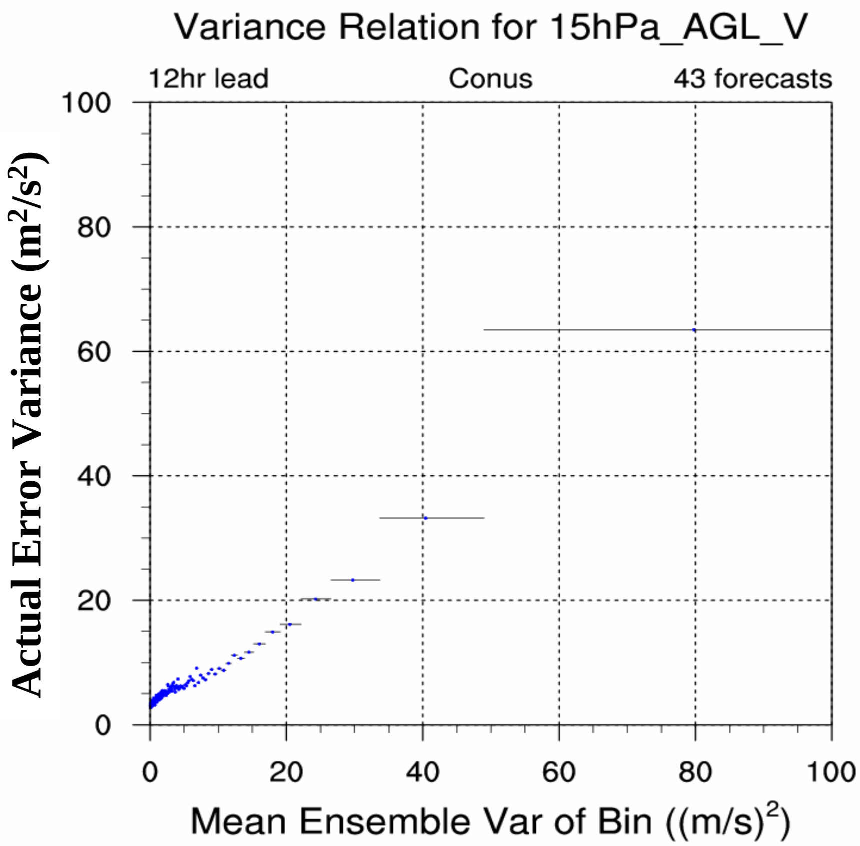
N is the number of ensemble members

s_m is the scalar value of a single ensemble member

s_v is the scalar value of the verification

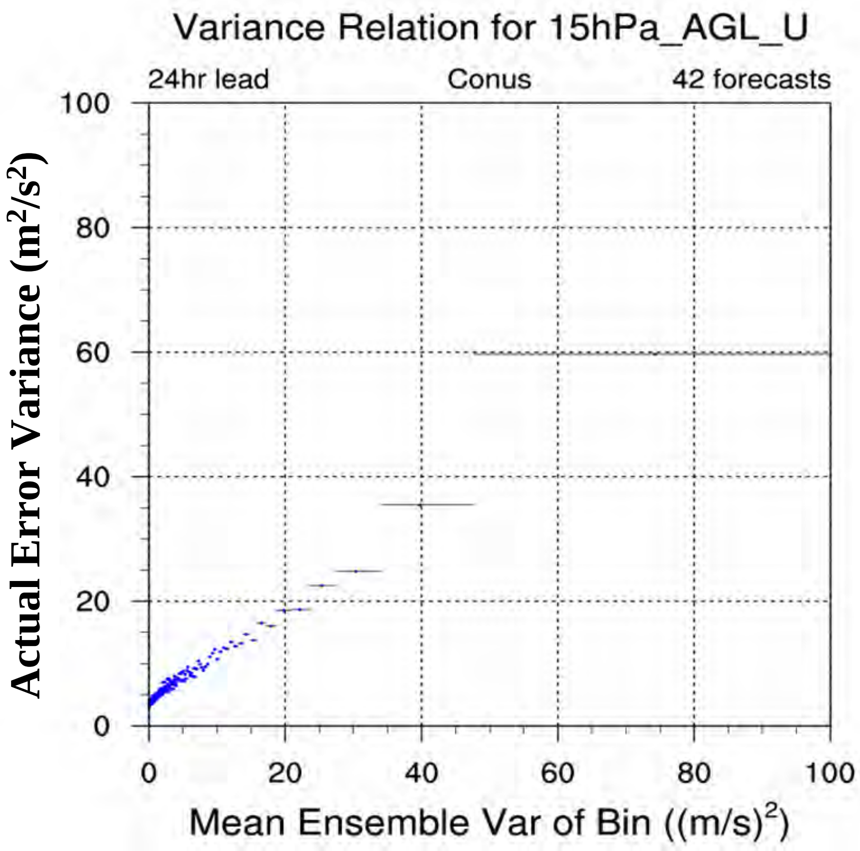
Linear Variance Calibration

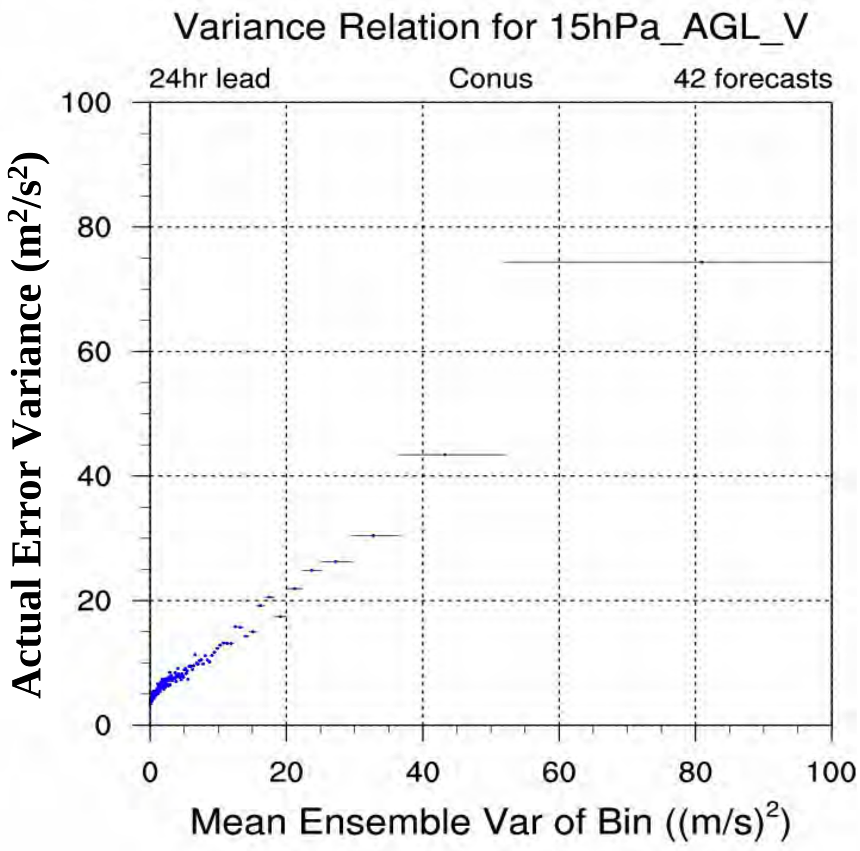




12 Hour Forecast

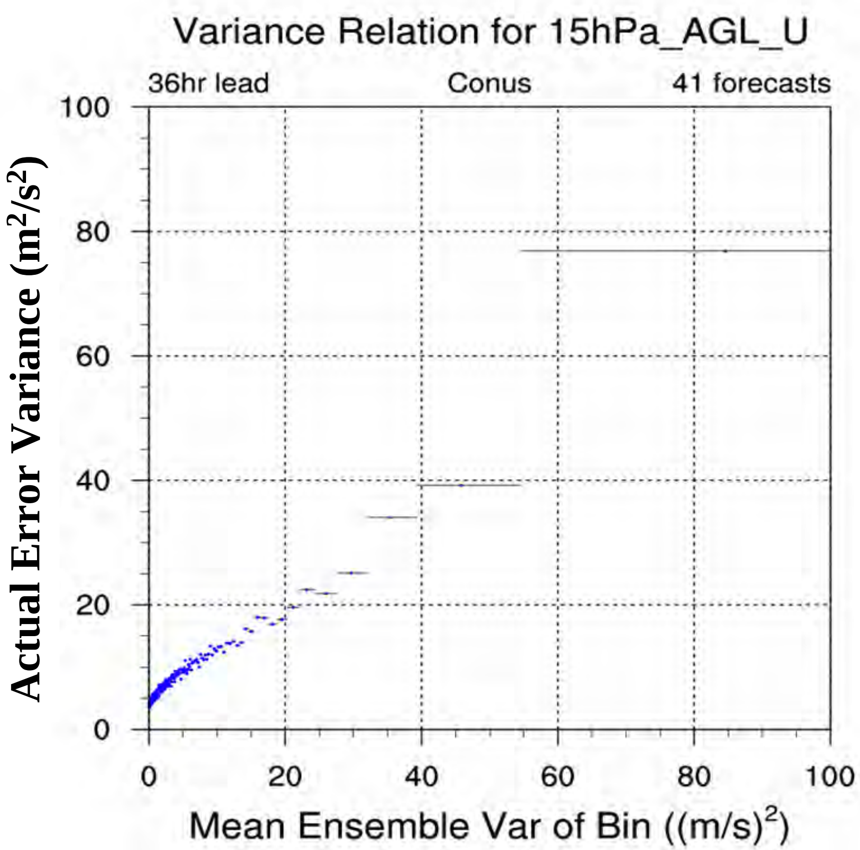
Linear Variance Calibration

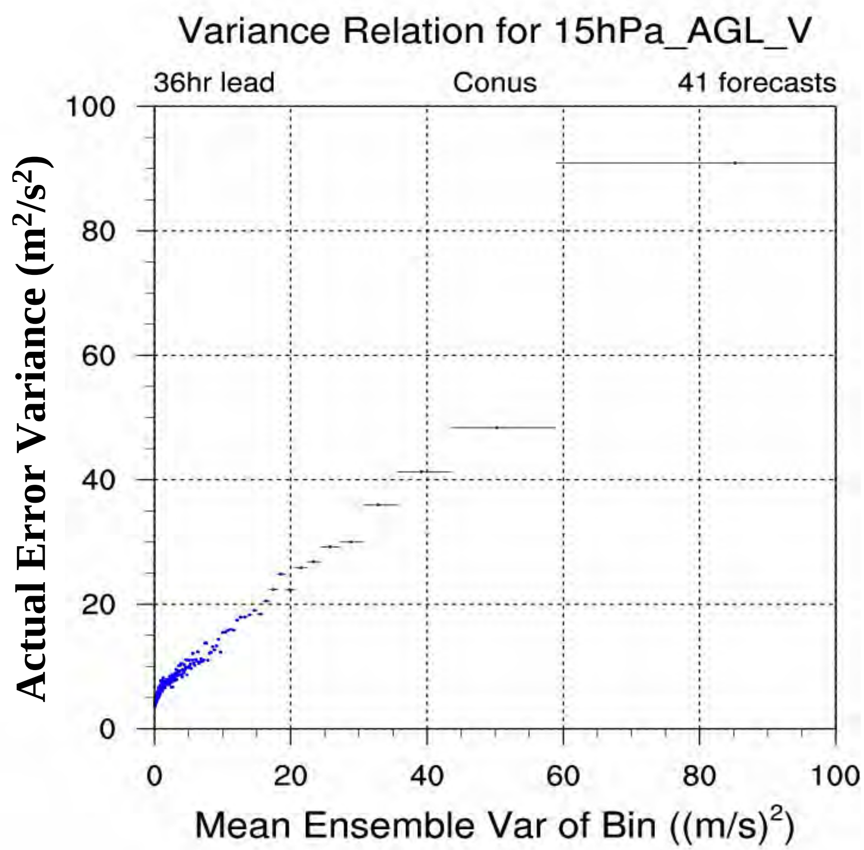




24 Hour Forecast

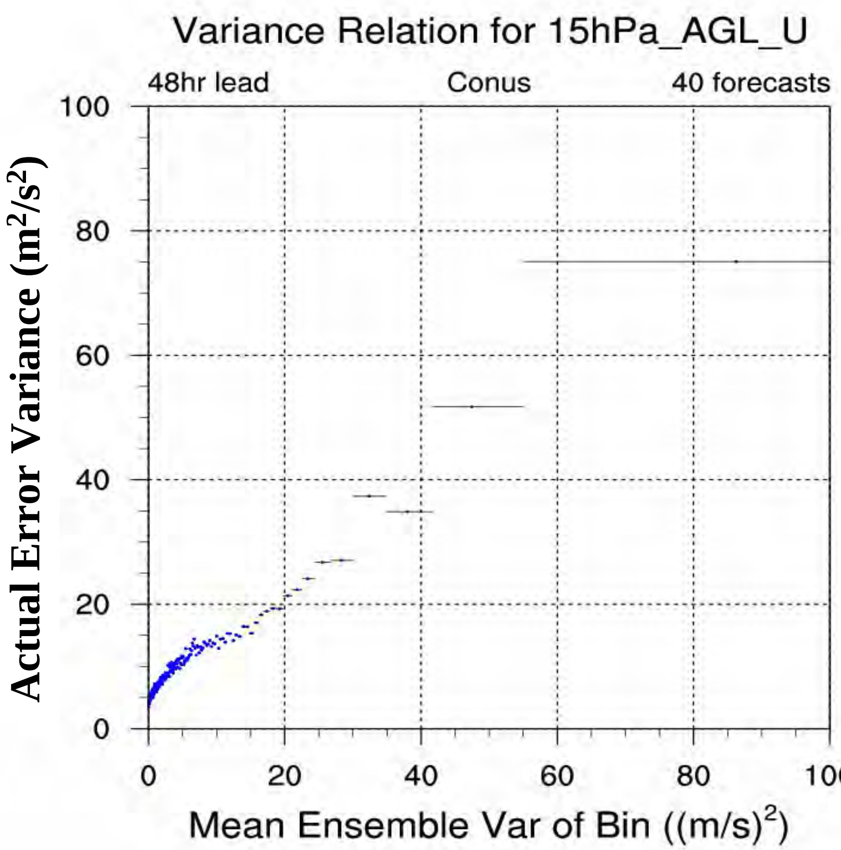
Linear Variance Calibration

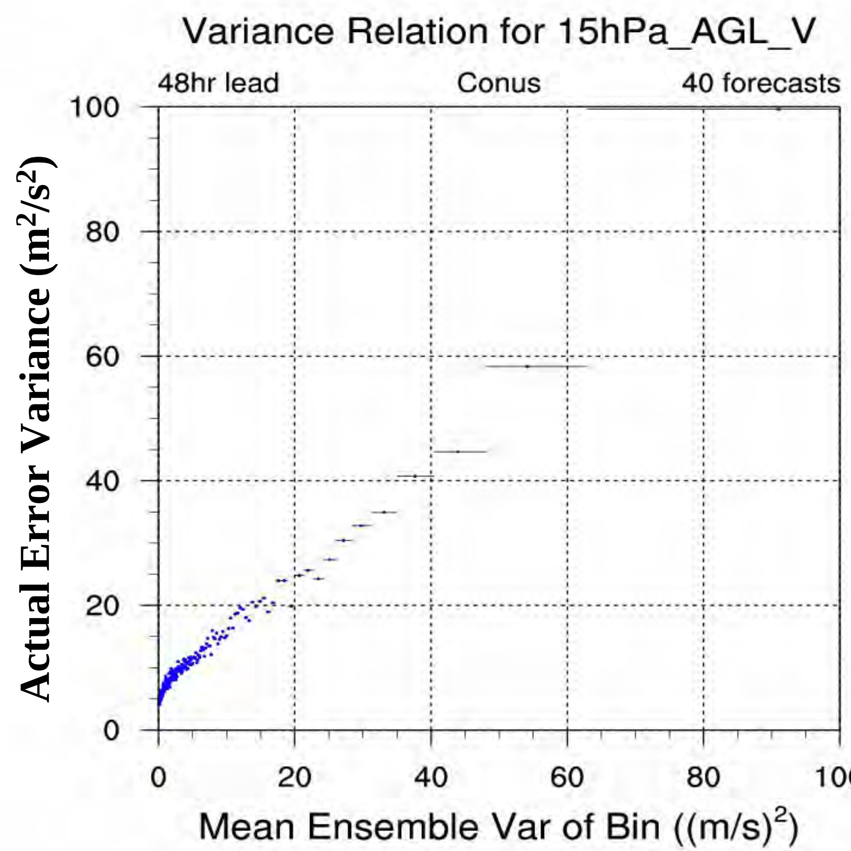




36 Hour Forecast

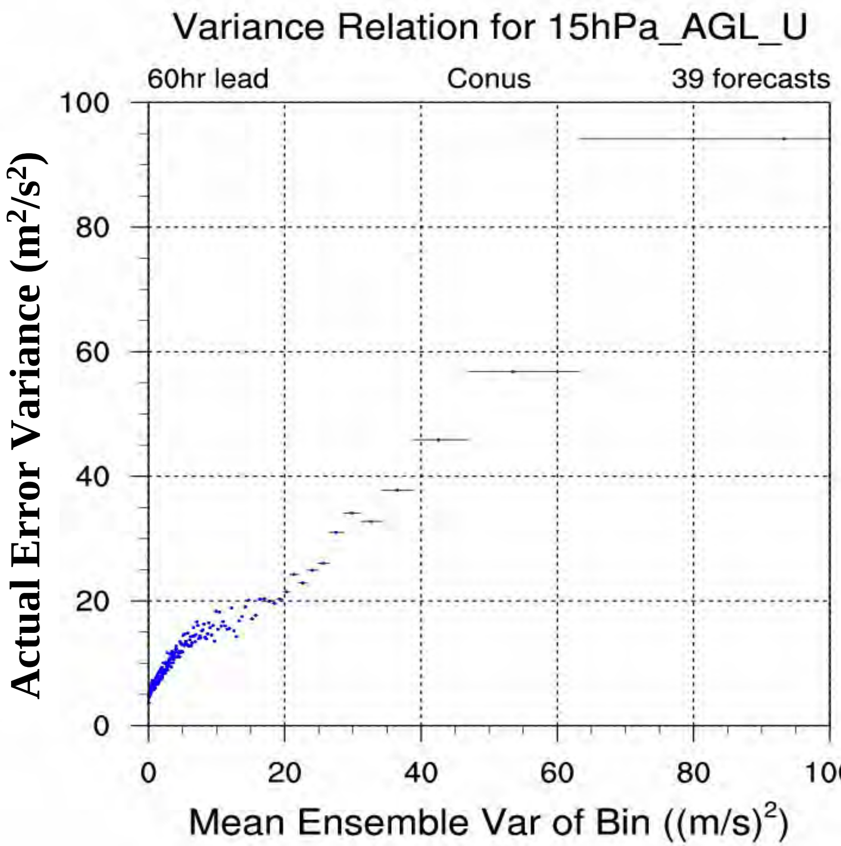
Linear Variance Calibration

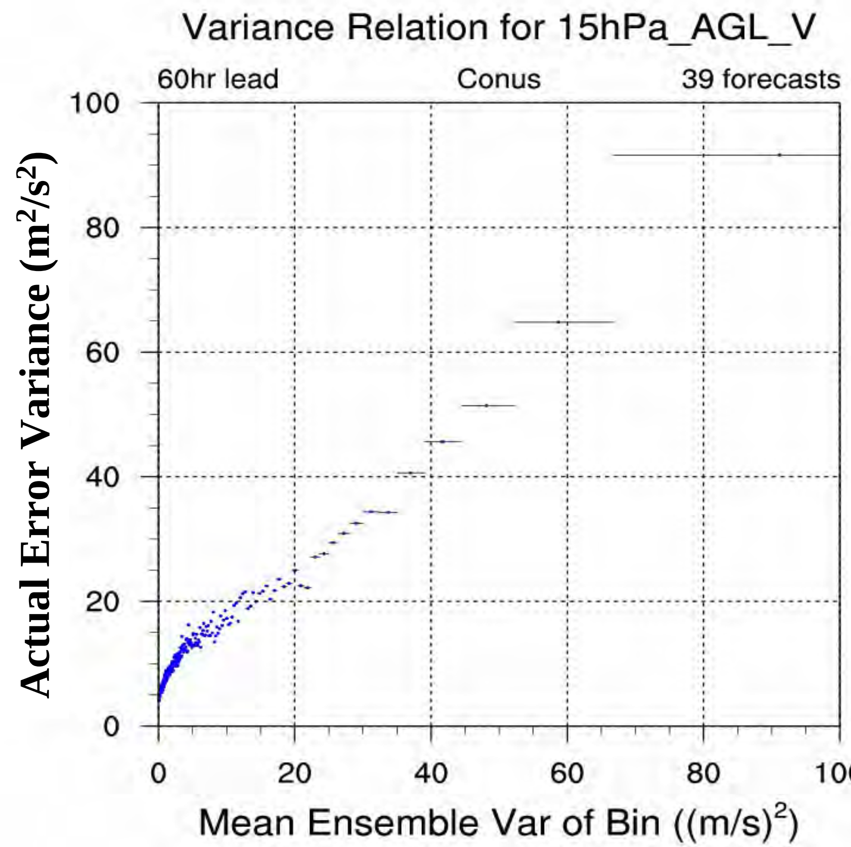




48 Hour Forecast

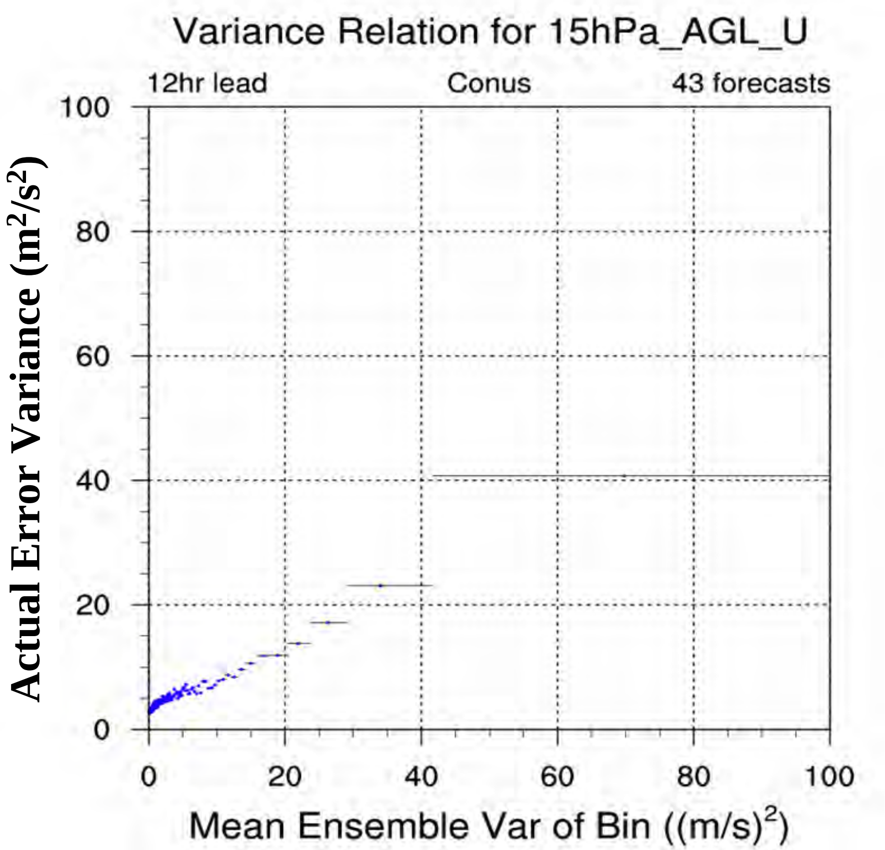
Linear Variance Calibration

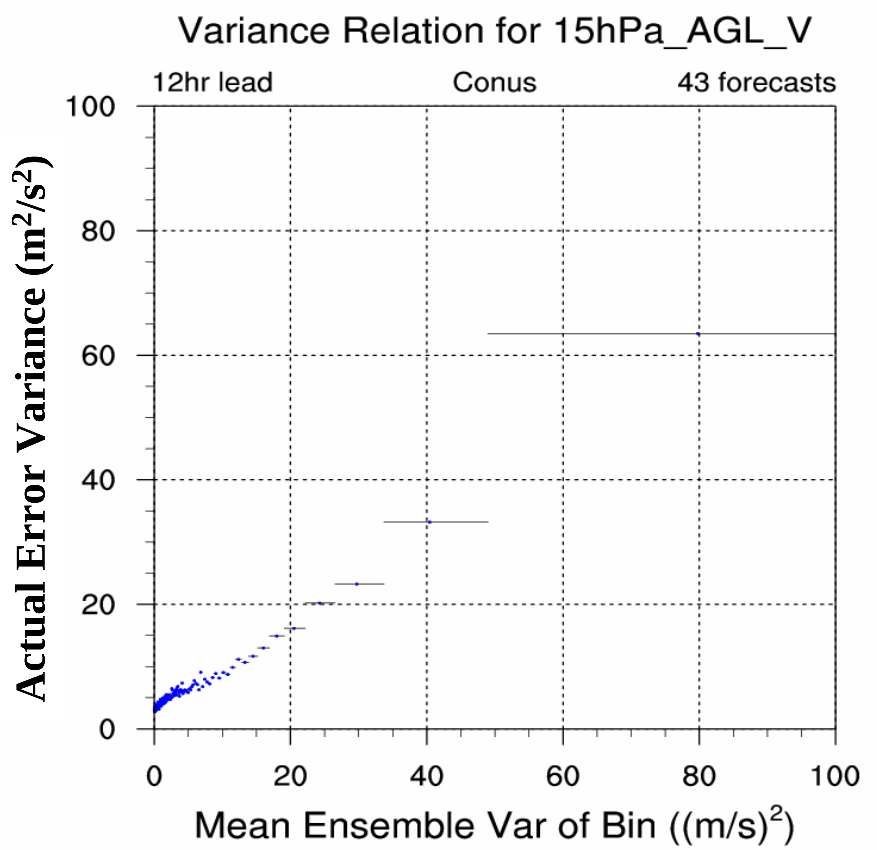




60 Hour Forecast

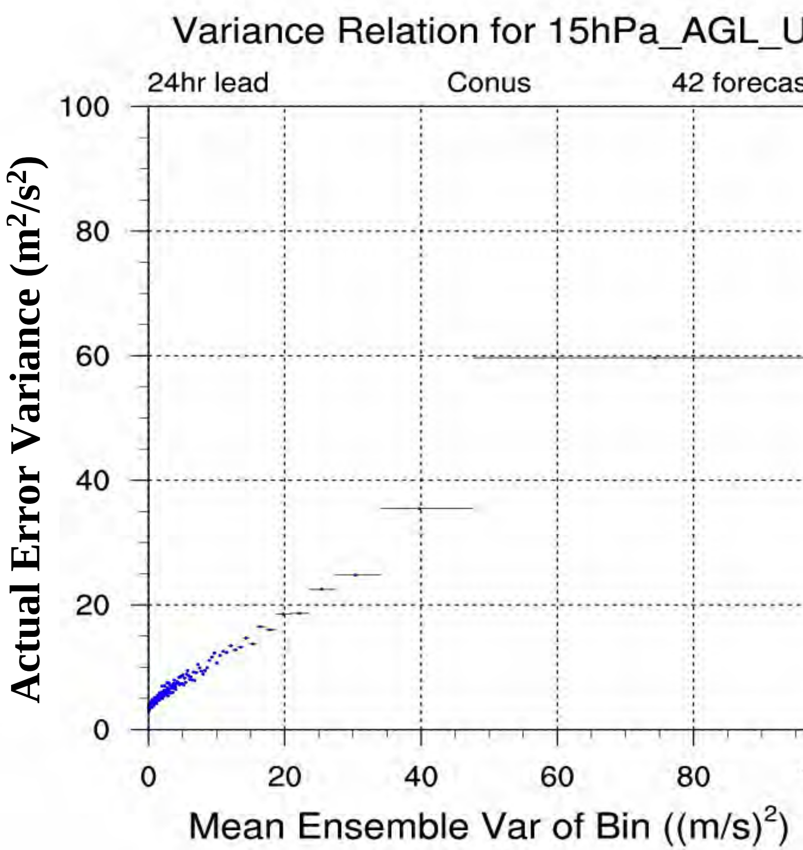
Linear Variance Calibration

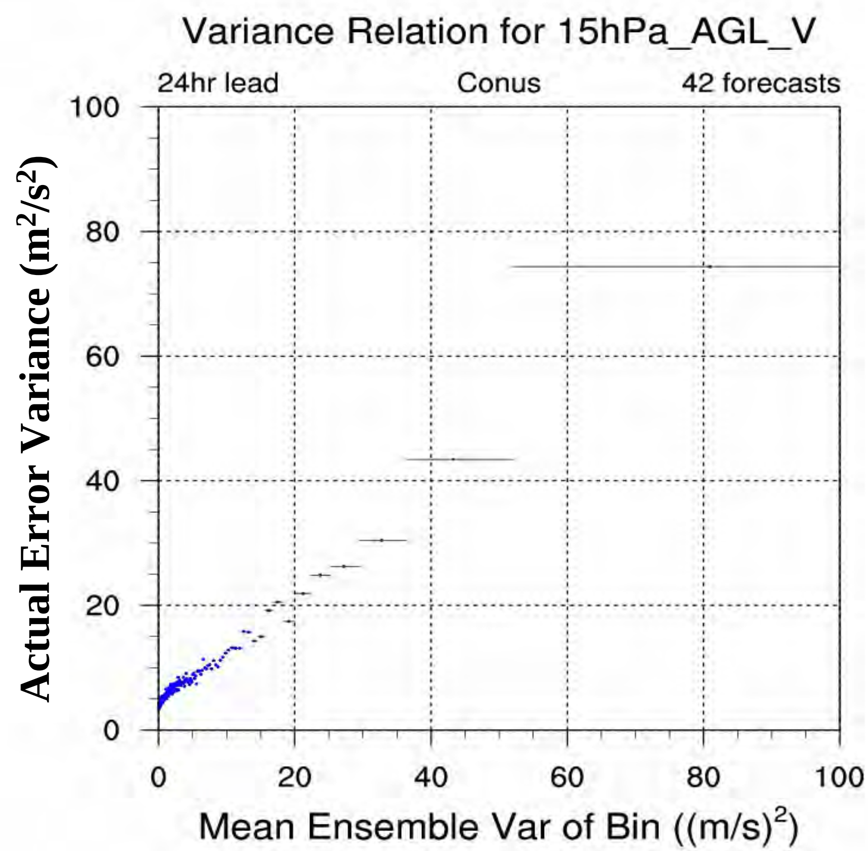




12 Hour Forecast

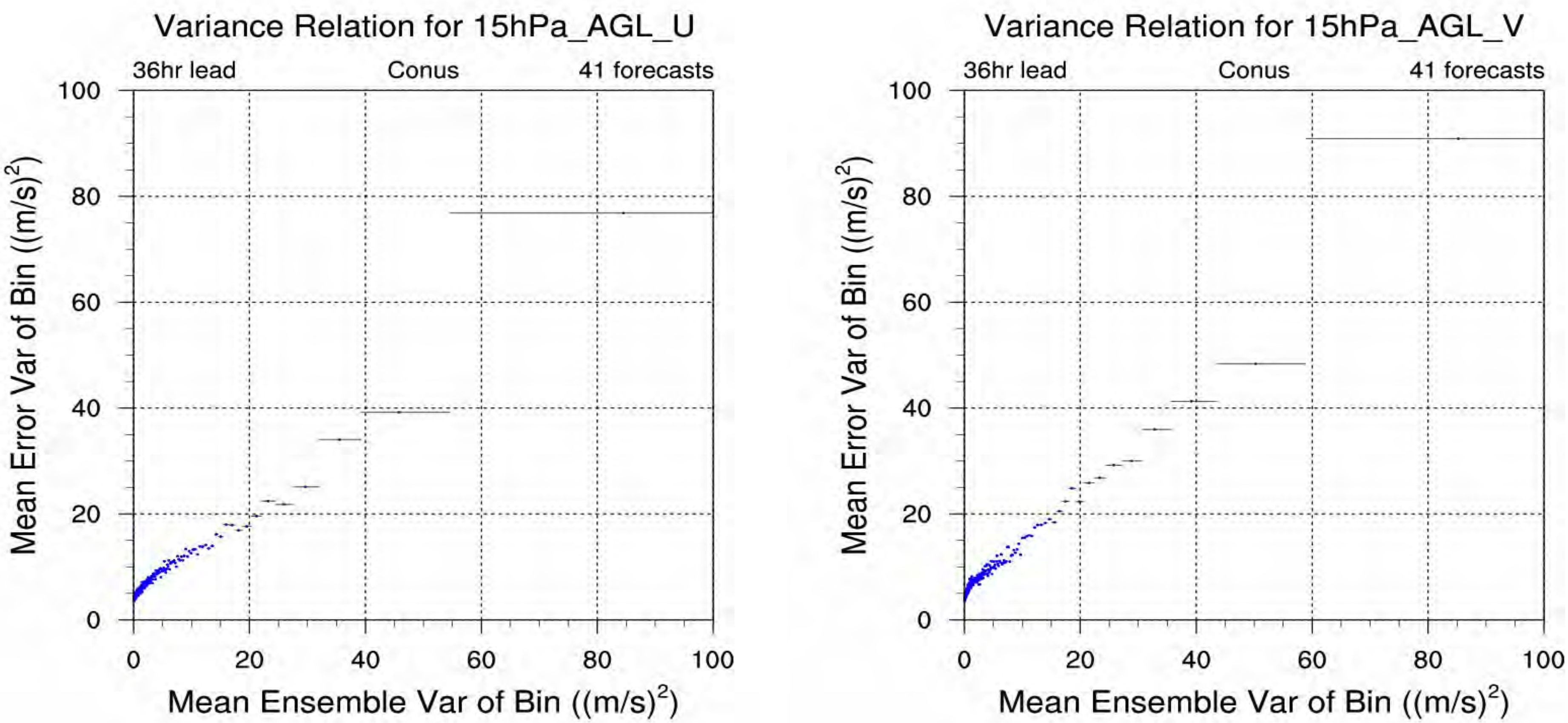
Linear Variance Calibration





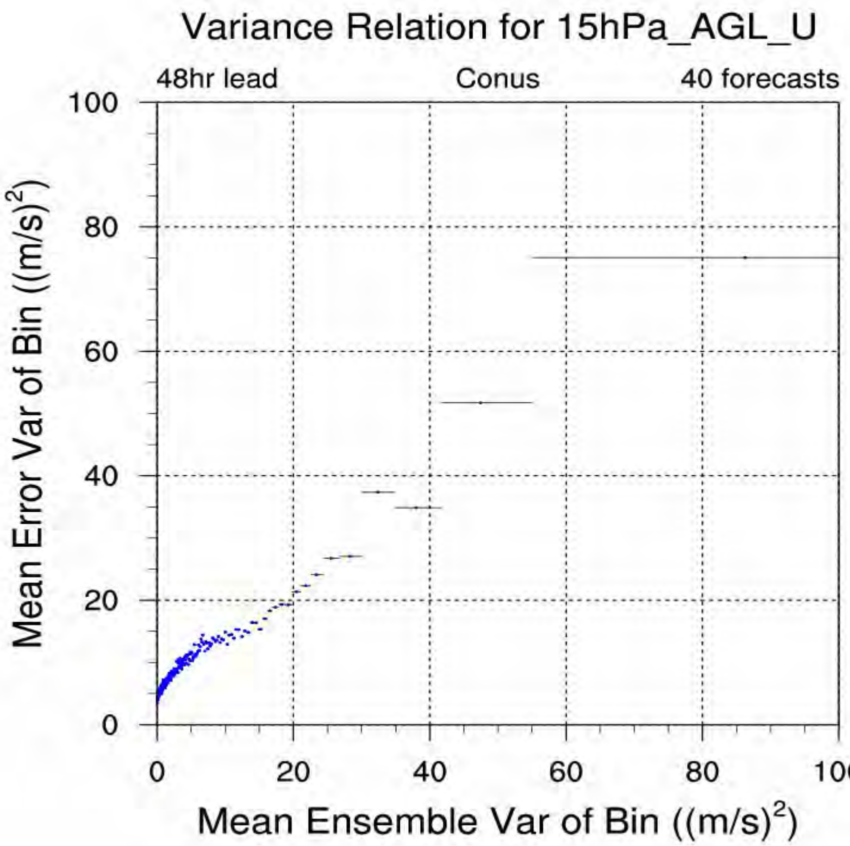
24 Hour Forecast

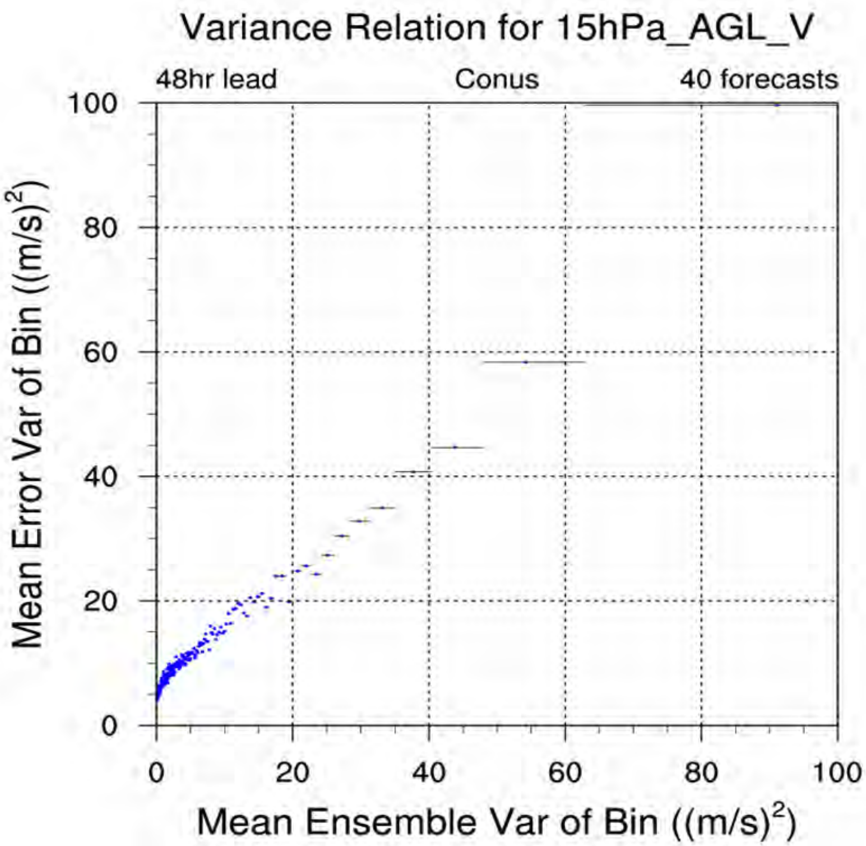
Linear Variance Calibration



36 Hour Forecast

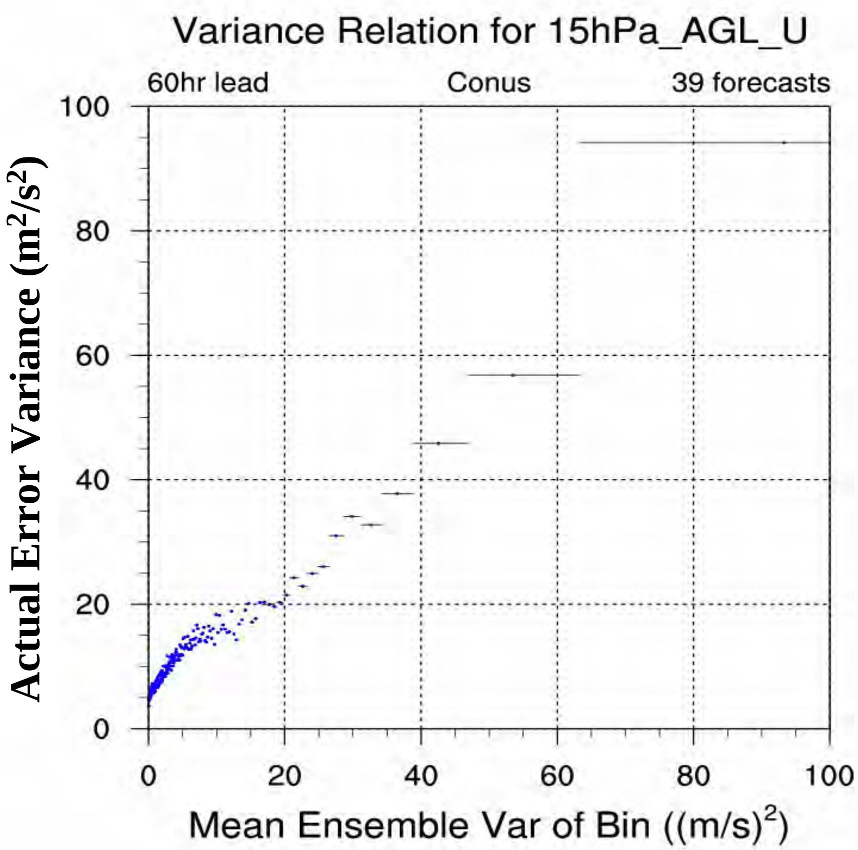
Linear Variance Calibration

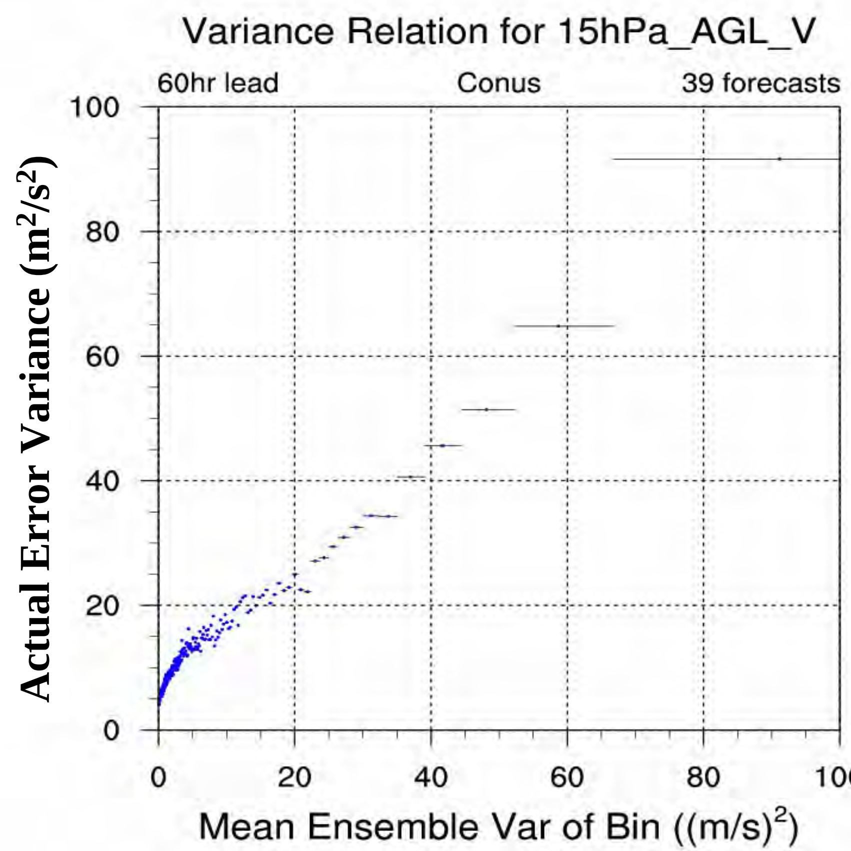




48 Hour Forecast

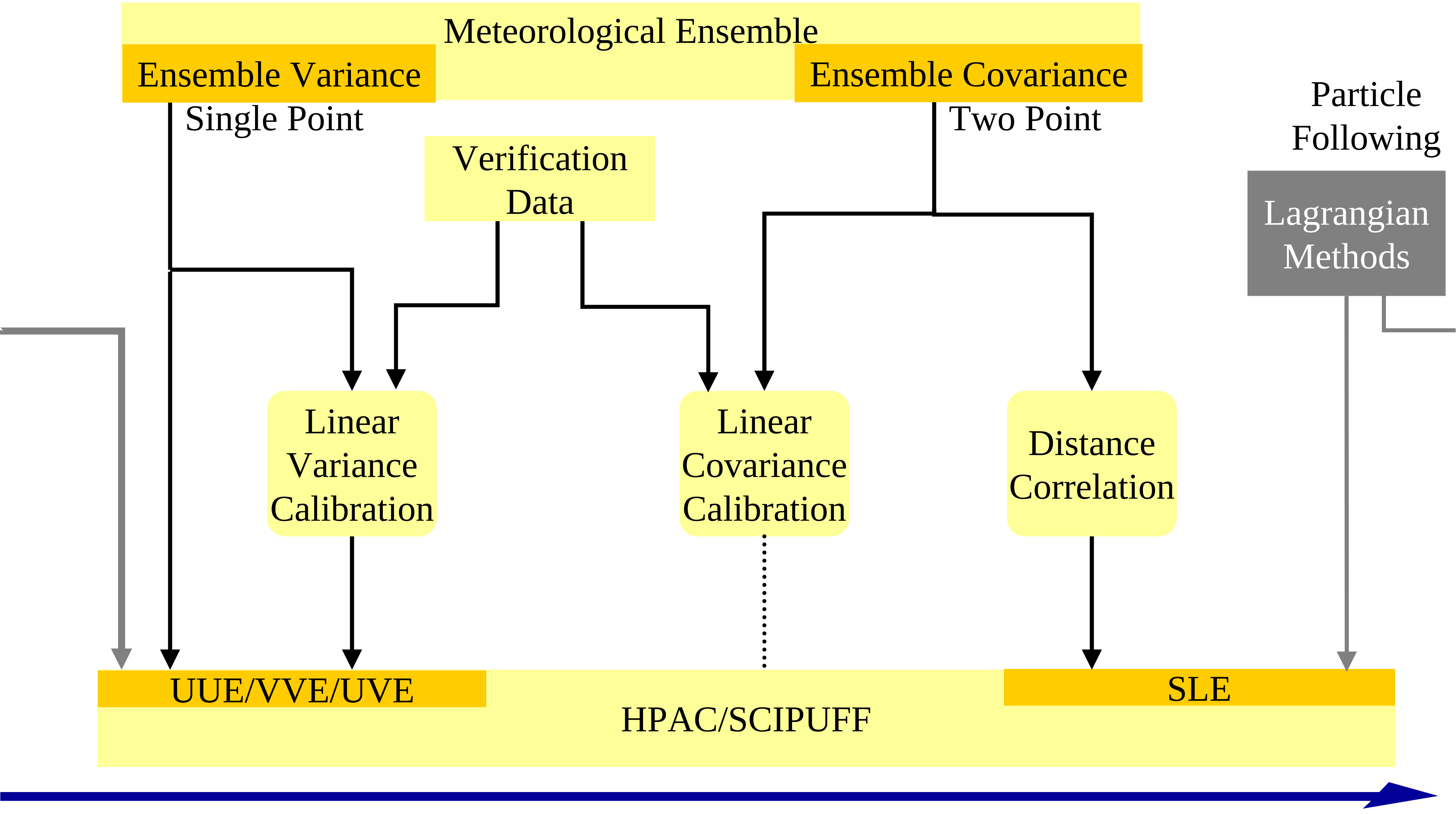
Linear Variance Calibration





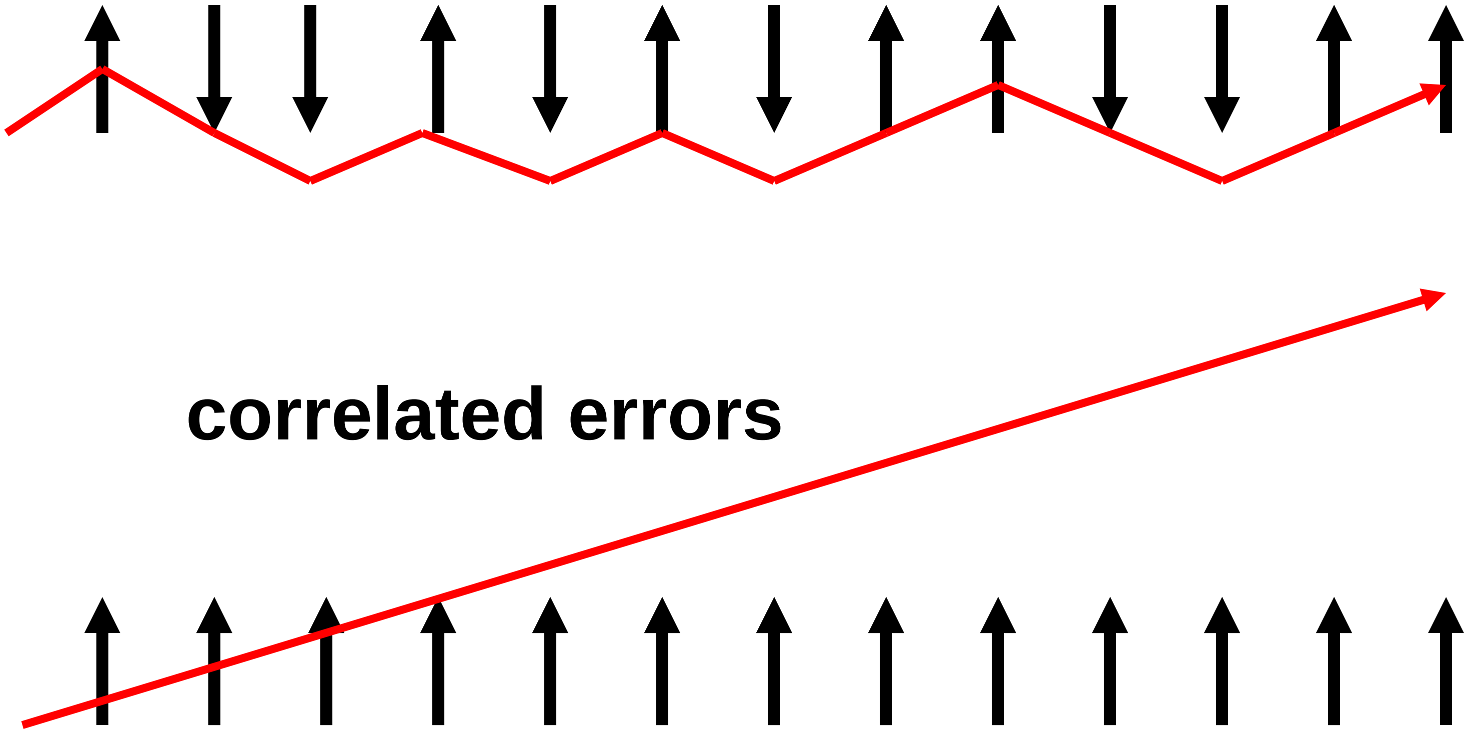
60 Hour Forecast

Linear Covariance Calibration



Linear Covariance Calibration

uncorrelated errors



correlated errors

(Roulston 2005b)

Linear Covariance Calibration

$$ECov\left(s(ij,kl)\right)=\frac{1}{N}\sum_{m=1}^{N}\left(s_m(ij)-\overline{s(ij)}\right)\left(s_m(kl)-\overline{s(kl)}\right)$$

$$ACov\left(s(ij,kl)\right)=\left(s_v(ij)-\overline{s(ij)}\right)\left(s_v(kl)-\overline{s(kl)}\right)$$

$s(ij)$ is the value of a scalar field at point (i,j)

$ECov\left(s(ij,kl)\right)$ is the Ensemble Covariance of s between (i,j) and (k.l)

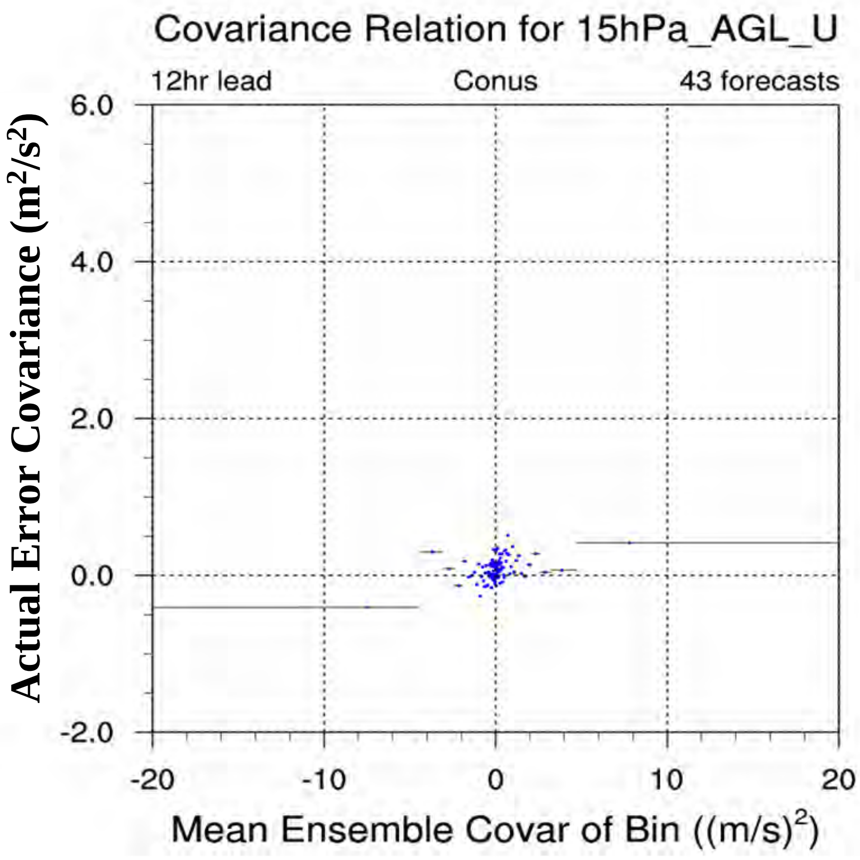
$AVar\left(s(kl)\right)$ is the Actual Covariance of s between (i,j) and (k,l)

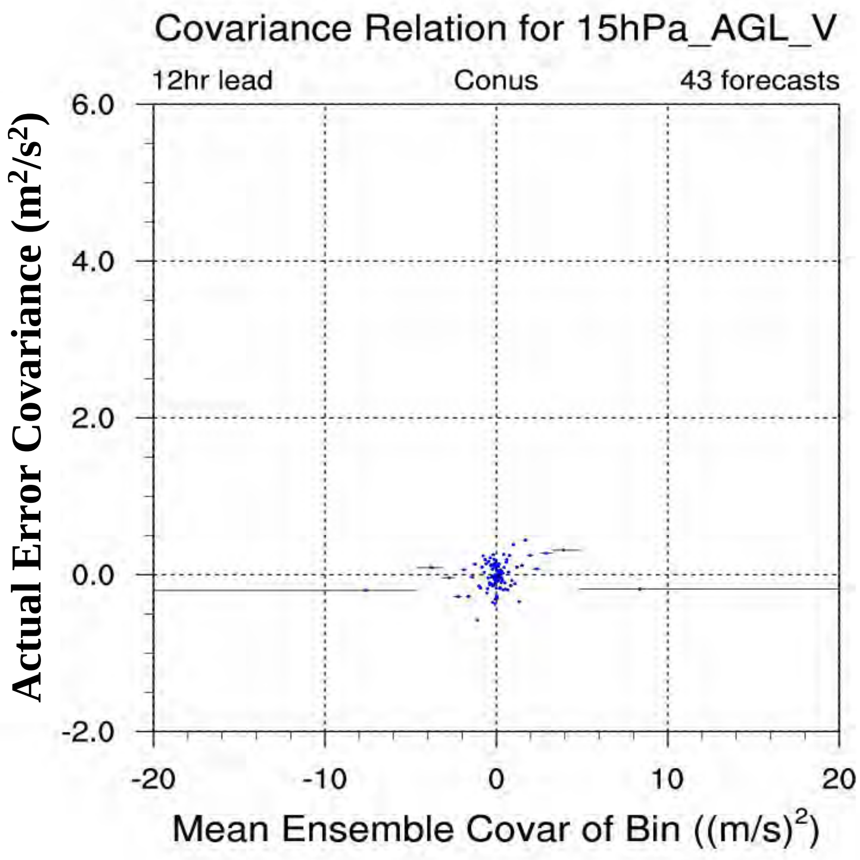
N is the number of ensemble members

s_m is the scalar value of a single ensemble member

s_v is the scalar value of the verification

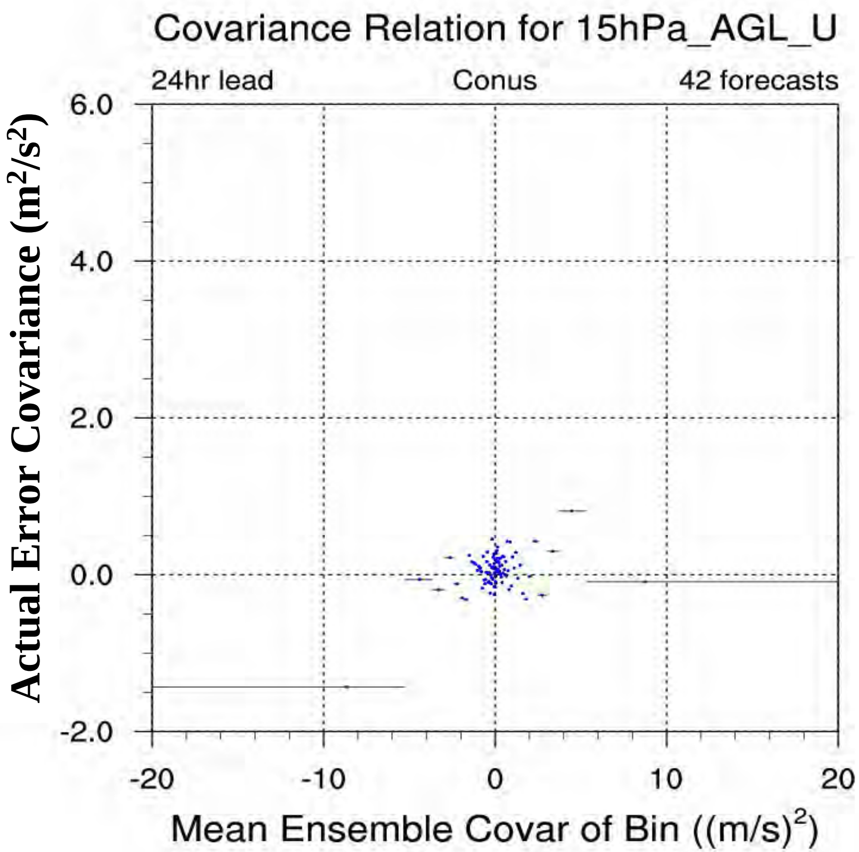
Linear Covariance Calibration

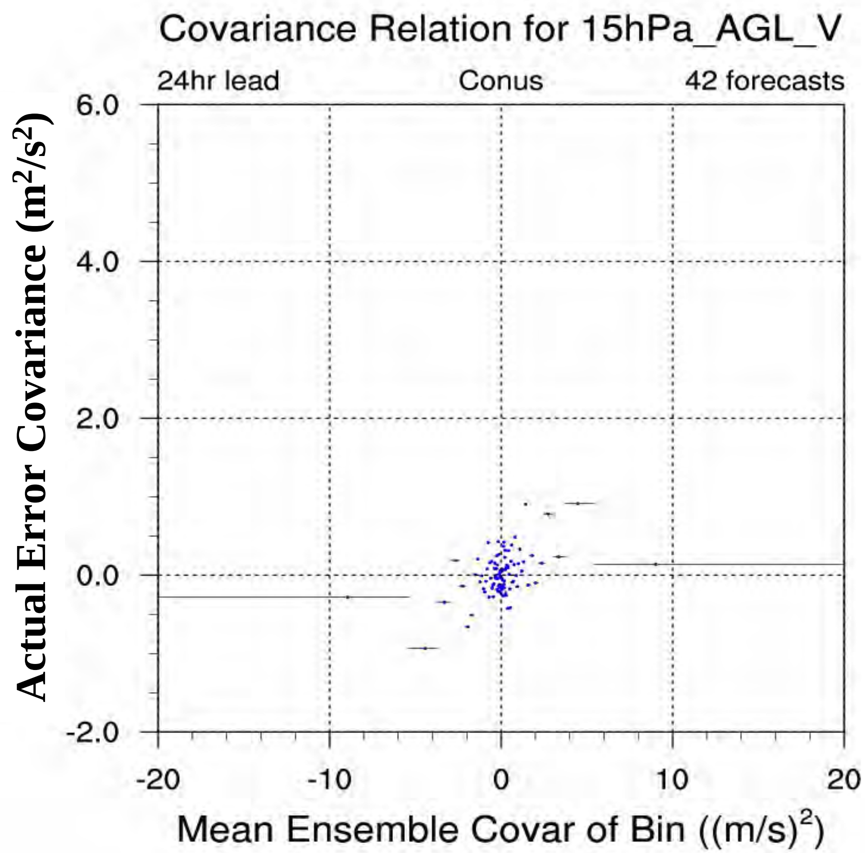




12 Hour Forecast

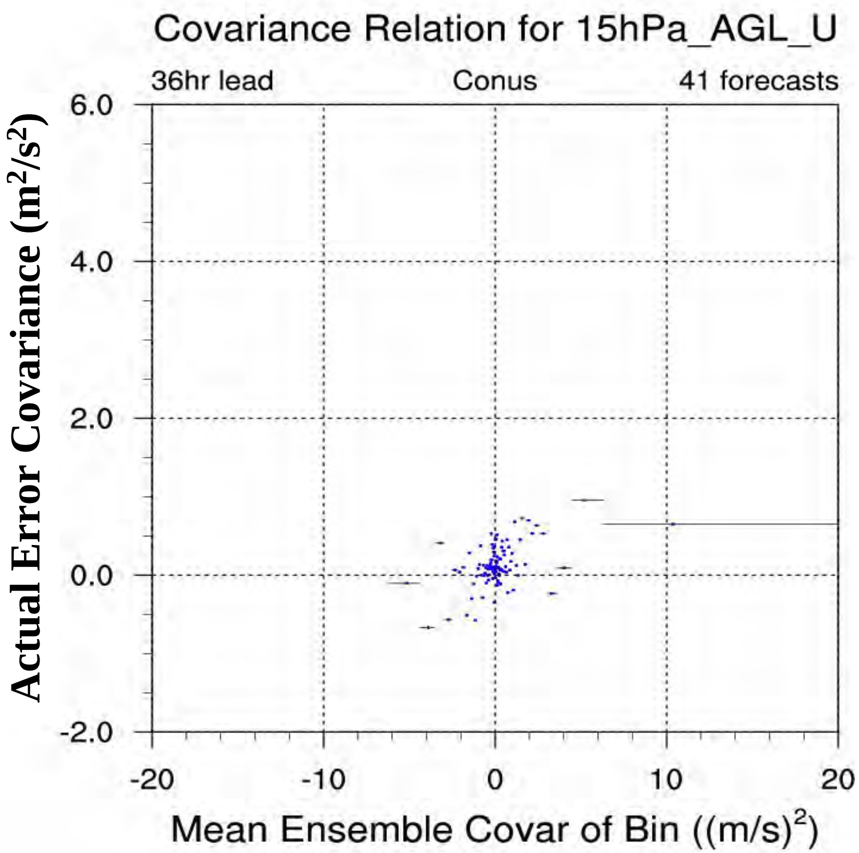
Linear Covariance Calibration

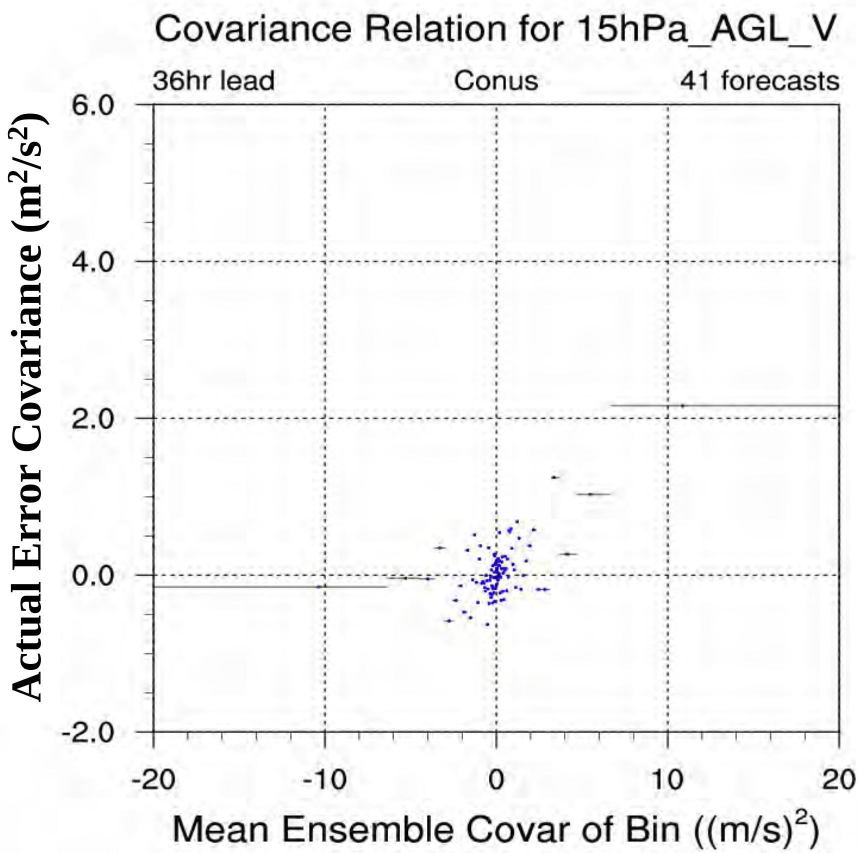




24 Hour Forecast

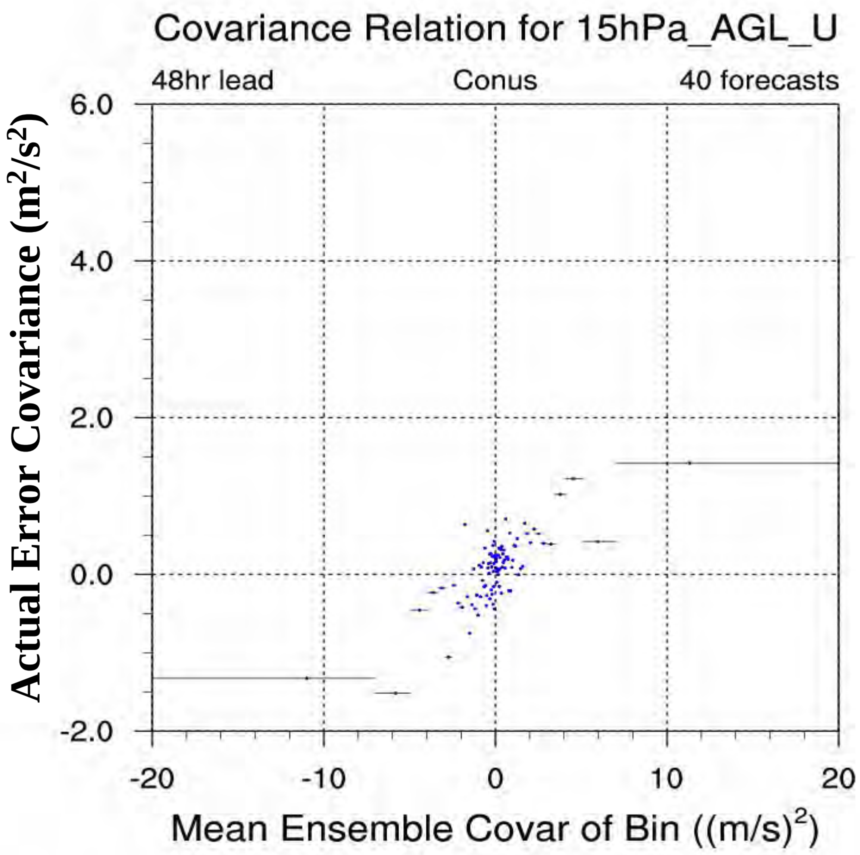
Linear Covariance Calibration

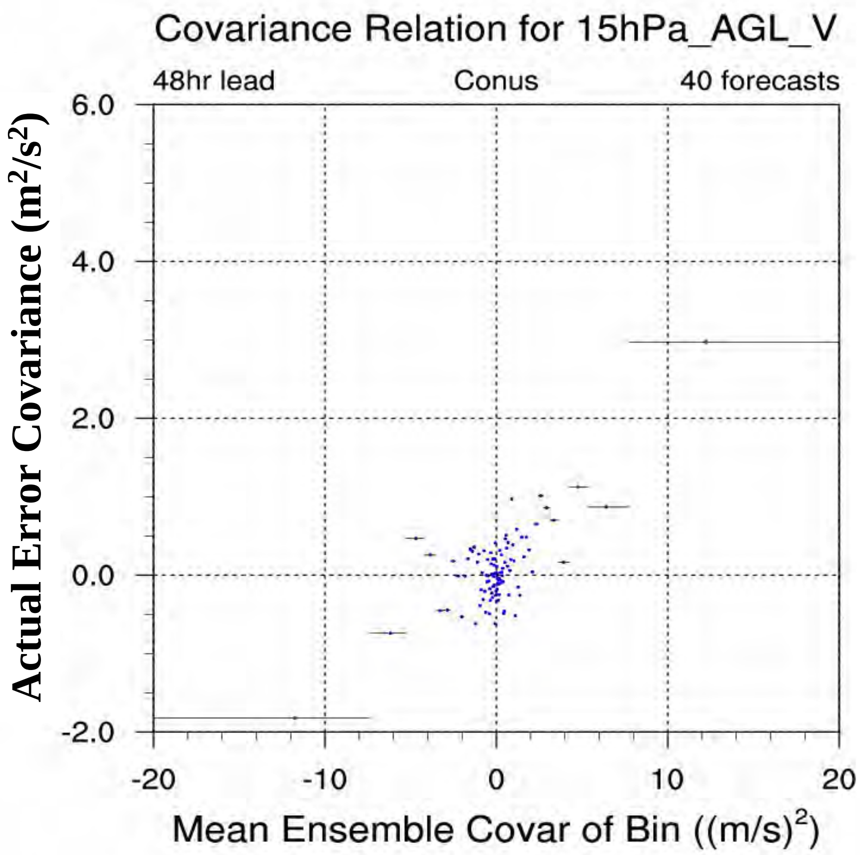




36 Hour Forecast

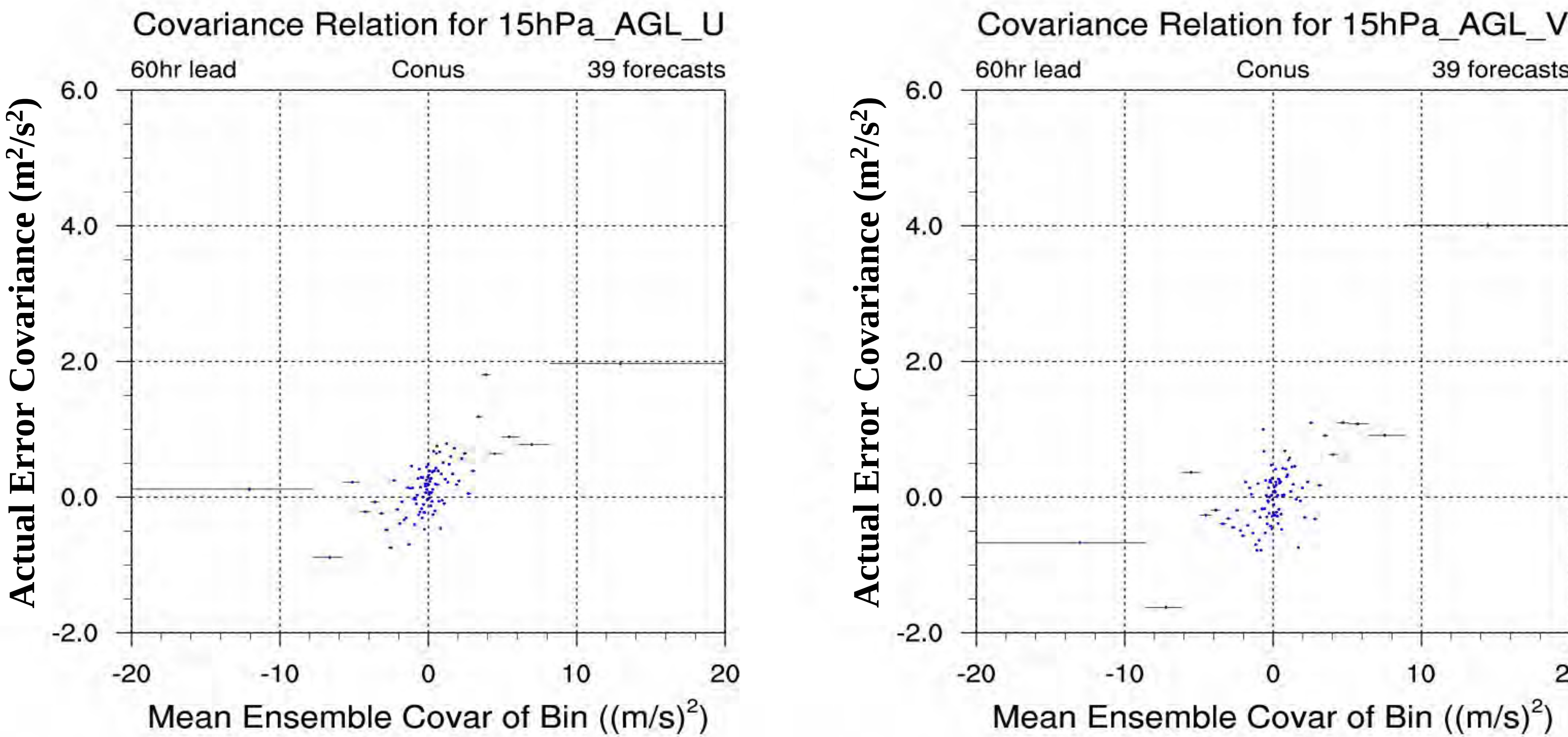
Linear Covariance Calibration





48 Hour Forecast

Linear Covariance Calibration



60 Hour Forecast

Linear Covariance Calibration

$$ECov\left(s(ij,kl)\right) = \frac{1}{N}\sum_{m=1}^{N}\left(s_m(ij) - s_c(ij)\right)\left(s_m(kl) - s_c(kl)\right)$$

$$ACov\left(s(ij,kl)\right) = \left(s_v(ij) - s_c(ij)\right)\left(s_v(kl) - s_c(kl)\right)$$

$s(ij)$ is the value of a scalar field at point (i,j)

$ECov\left(s(ij,kl)\right)$ is the Ensemble Covariance of s between (i,j) and (k.l)

$AVar\left(s(kl)\right)$ is the Actual Covariance of s between (i,j) and (k,l)

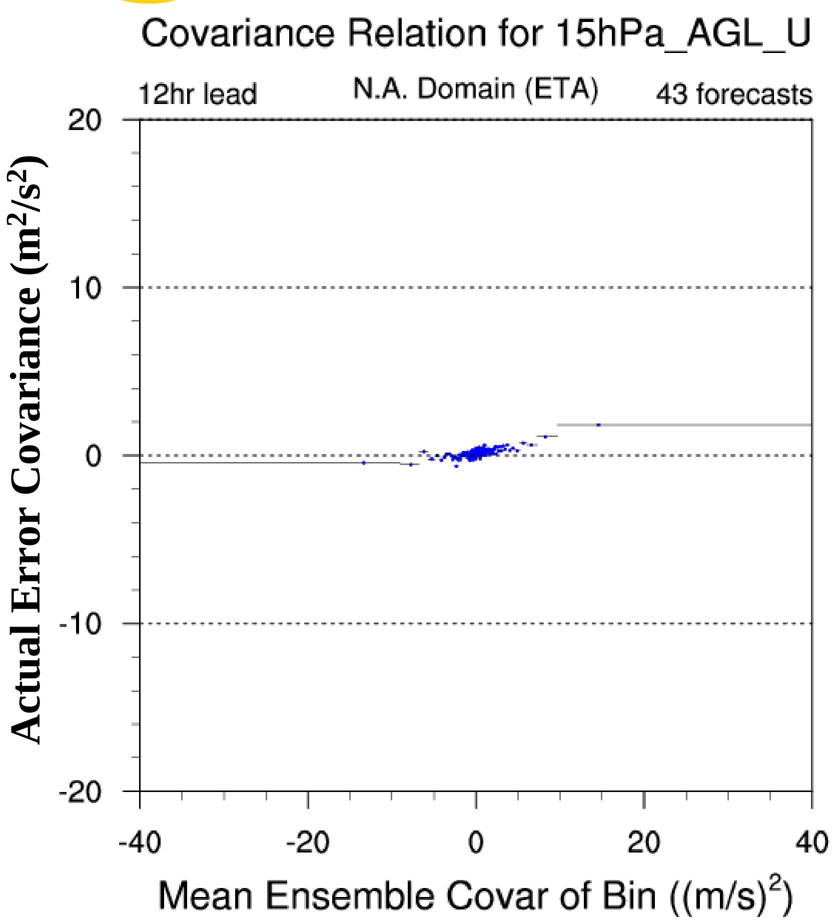
S_c is the scalar value of the control member

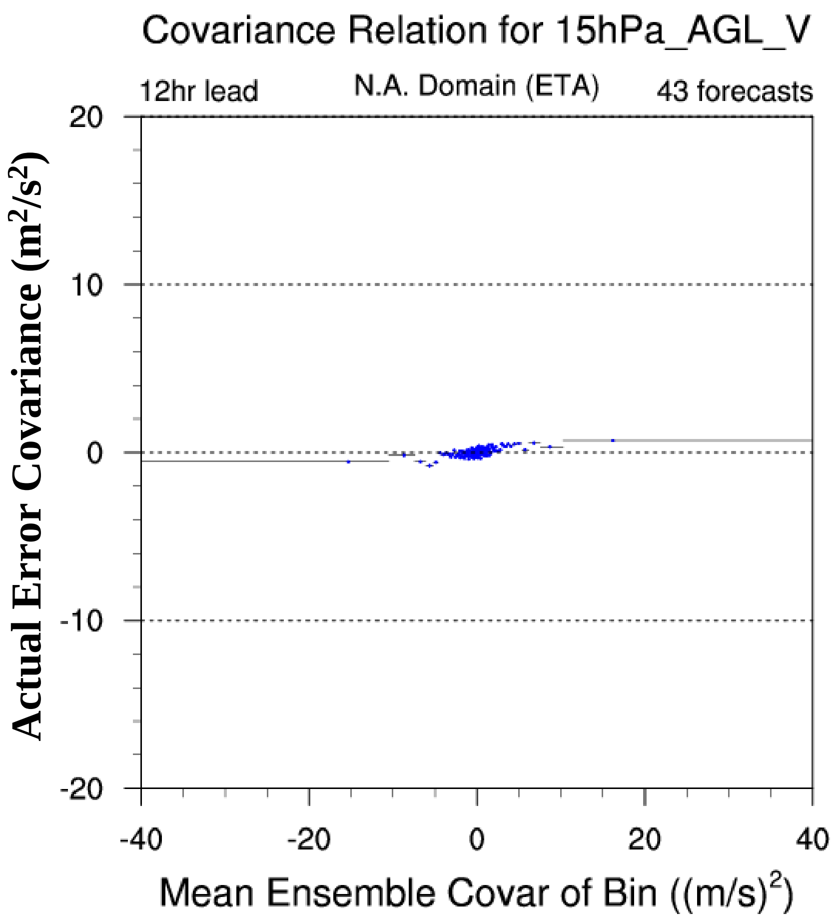
N number of ensemble members

S_m is the scalar value of a single ensemble member

S_v is the scalar value of the verification

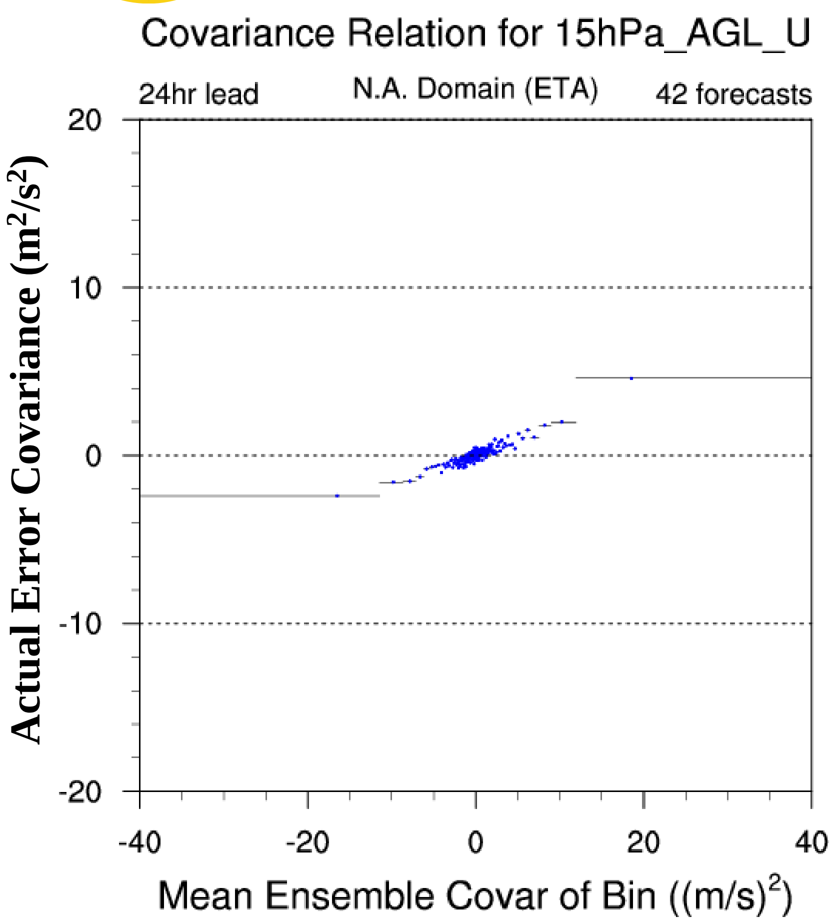
Linear Covariance Calibration - Control

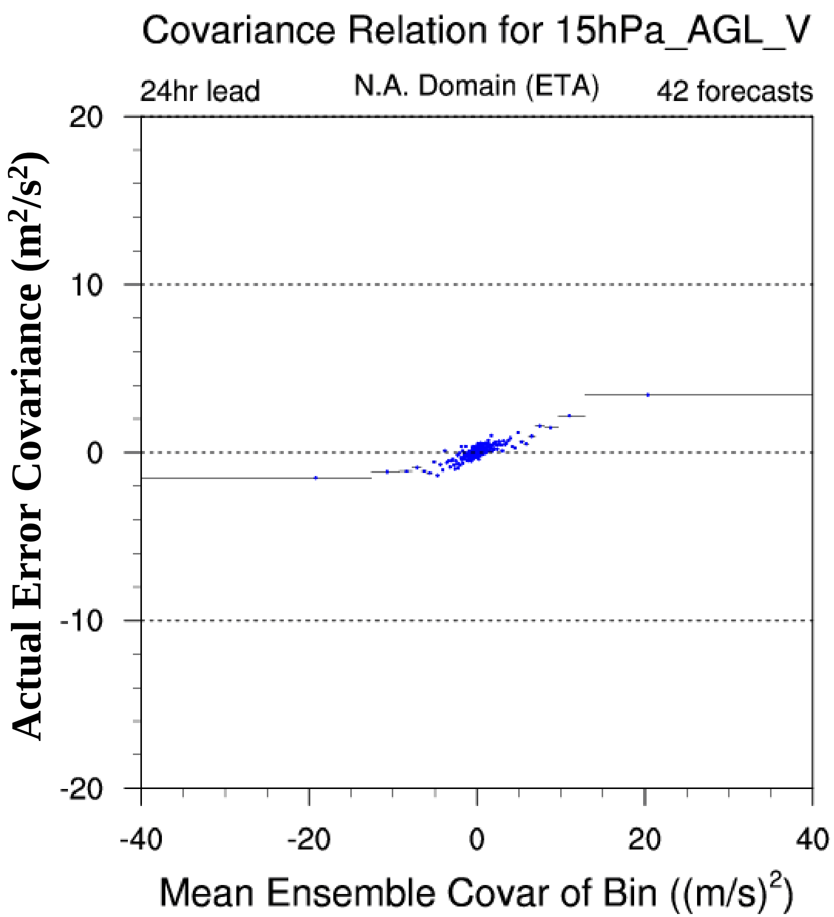




12 Hour Forecast

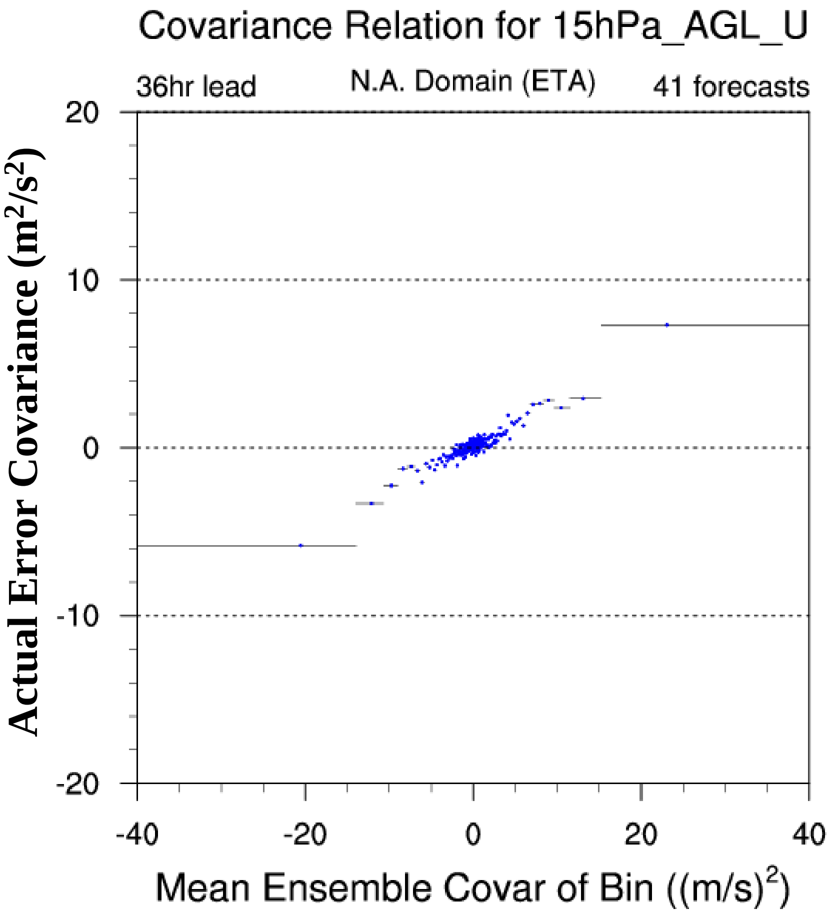
Linear Covariance Calibration - Control

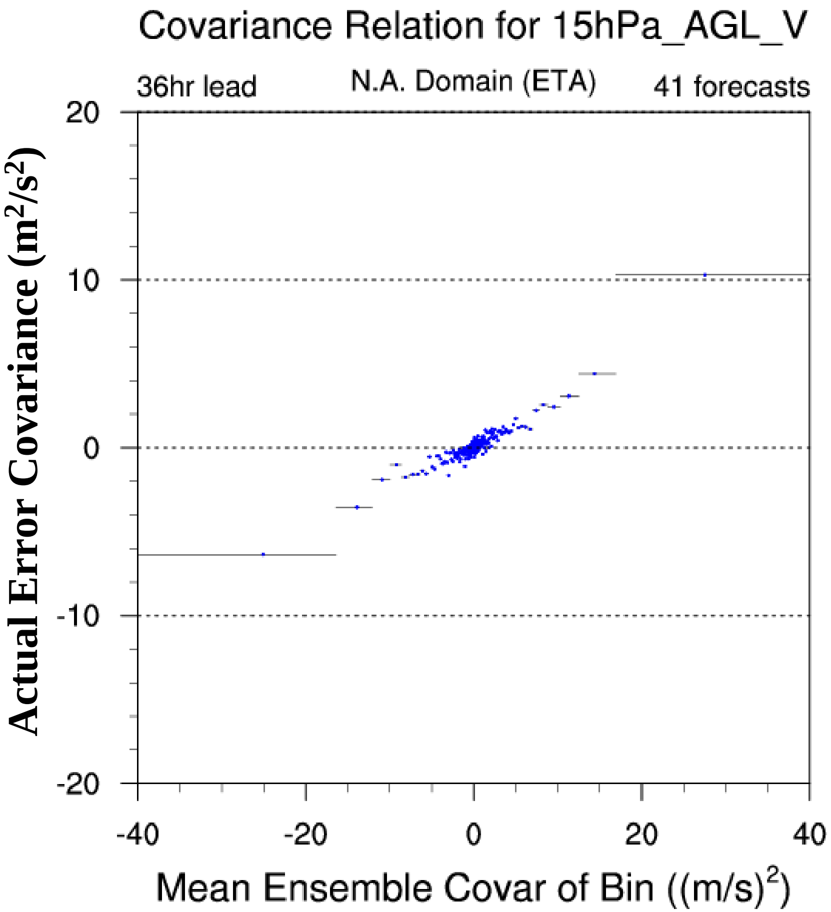




24 Hour Forecast

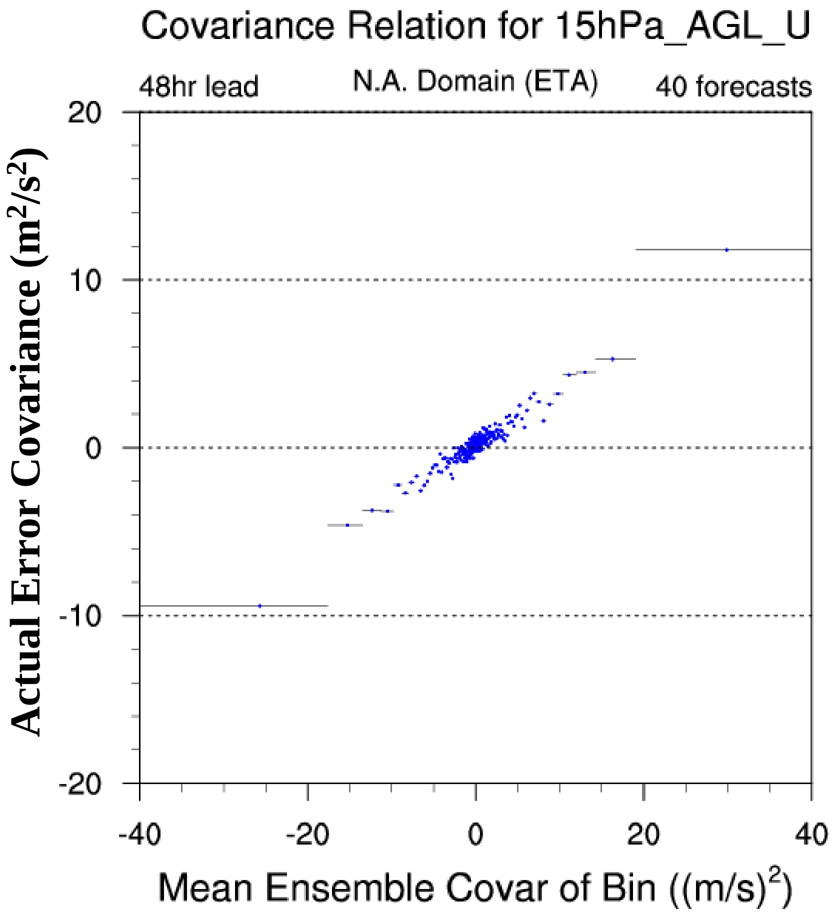
Linear Covariance Calibration - Control

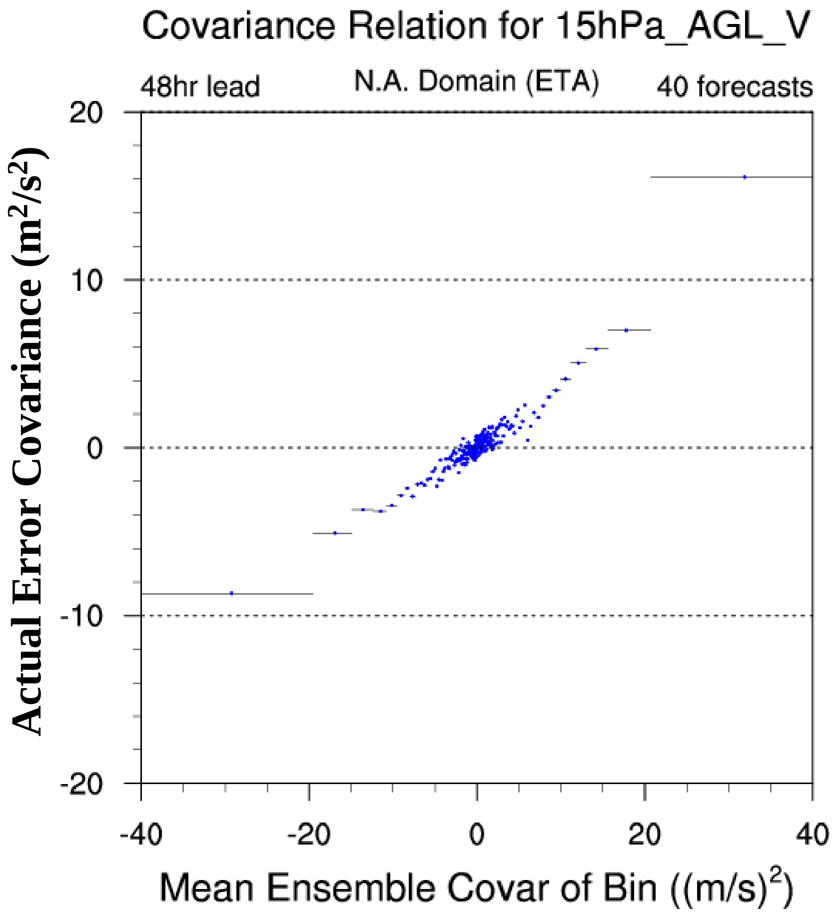




36 Hour Forecast

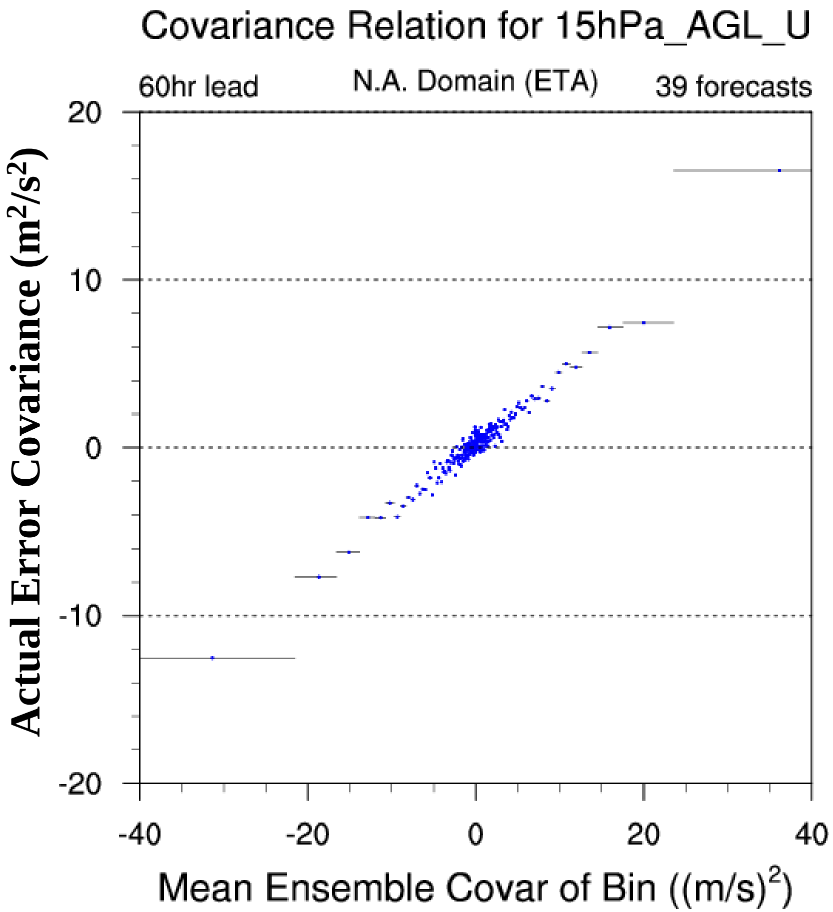
Linear Covariance Calibration - Control

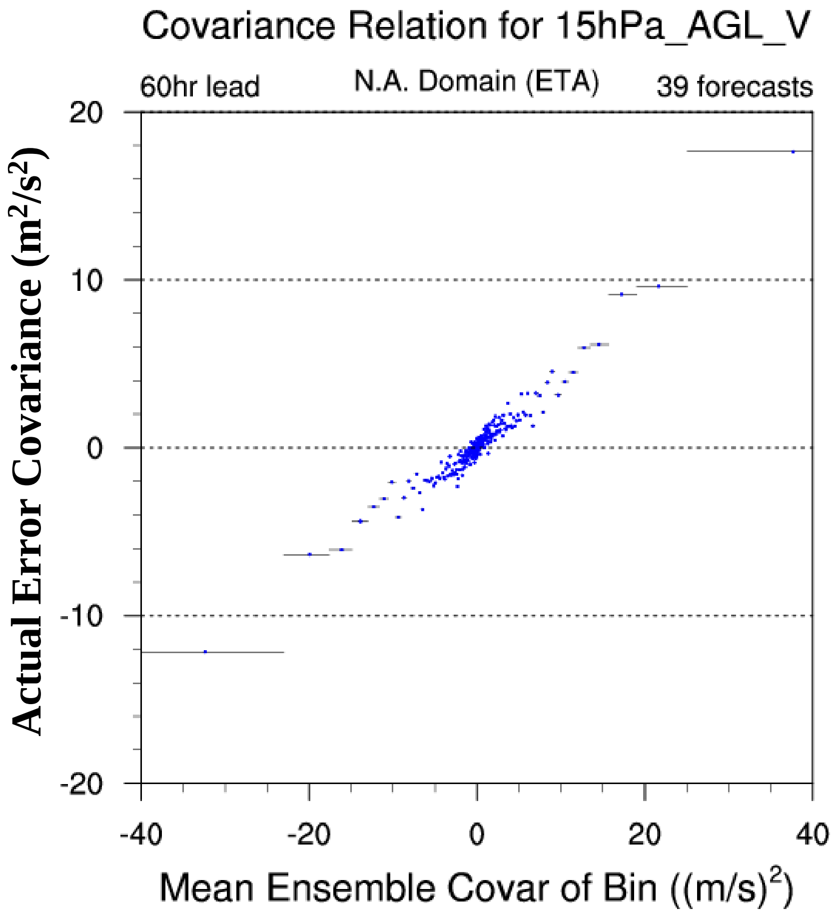




48 Hour Forecast

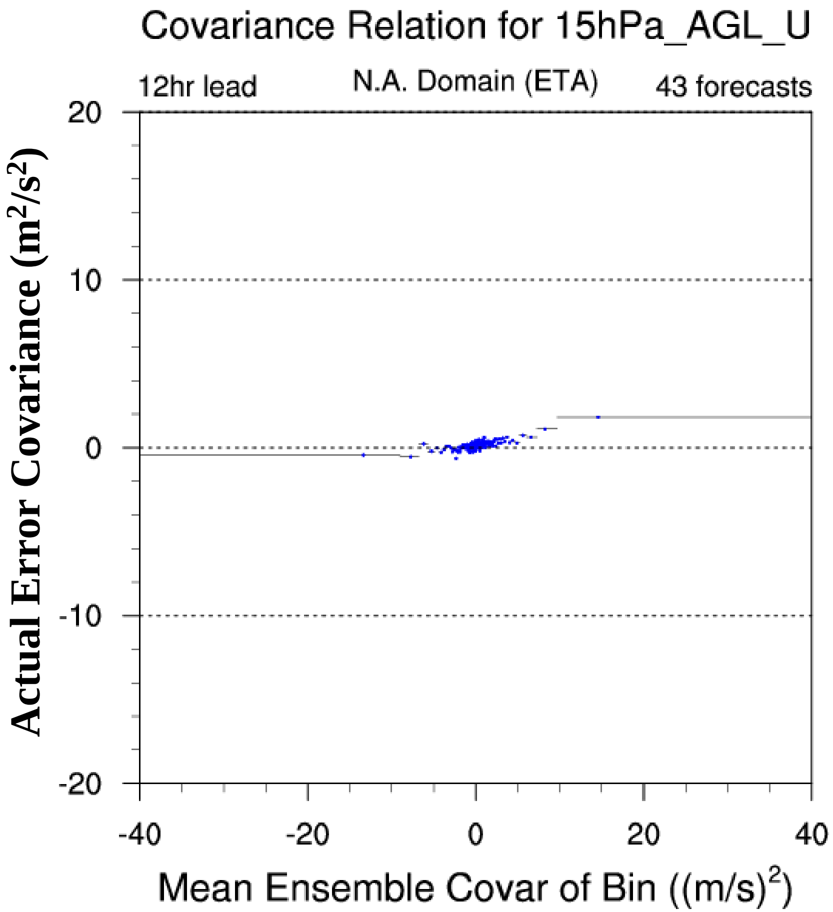
Linear Covariance Calibration - Control

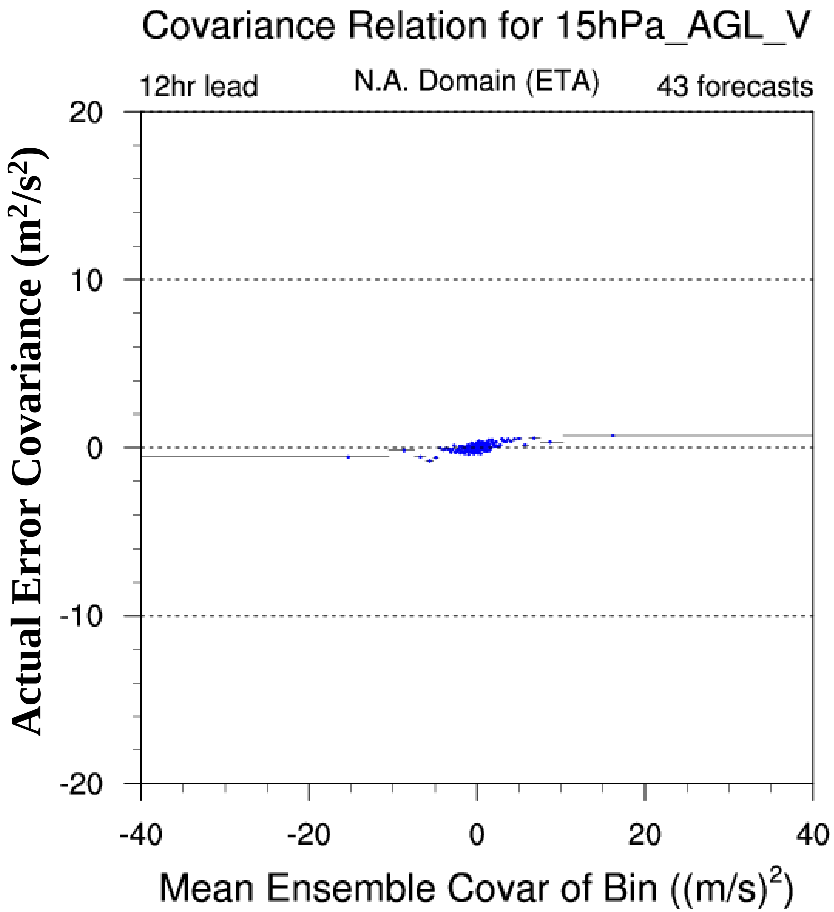




60 Hour Forecast

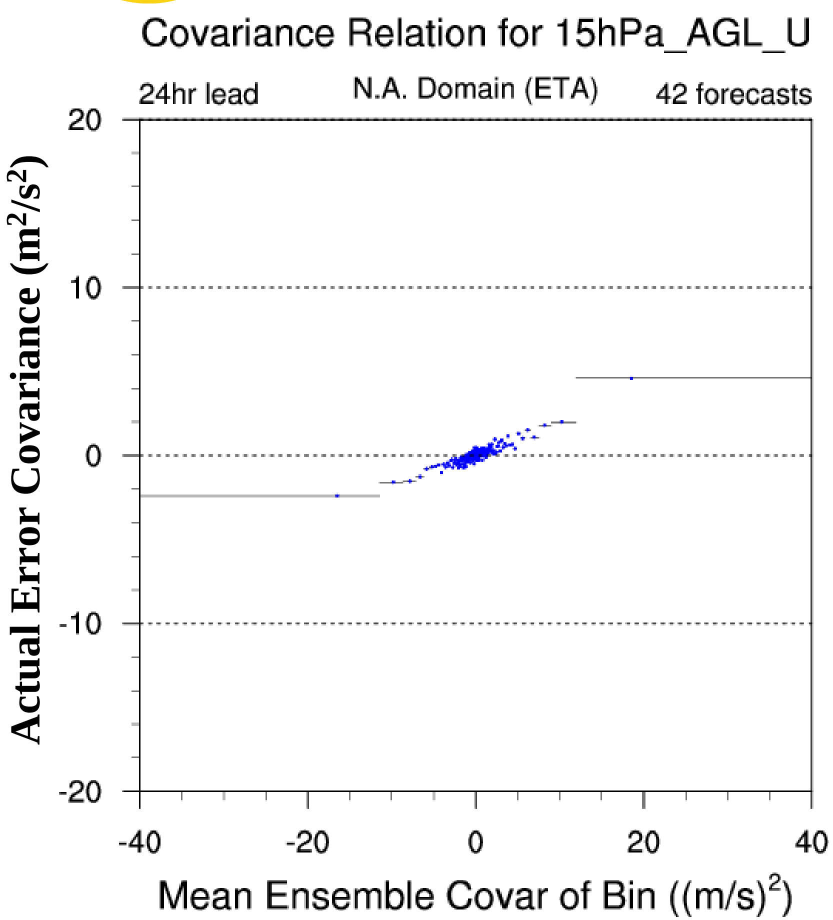
Linear Covariance Calibration - Control

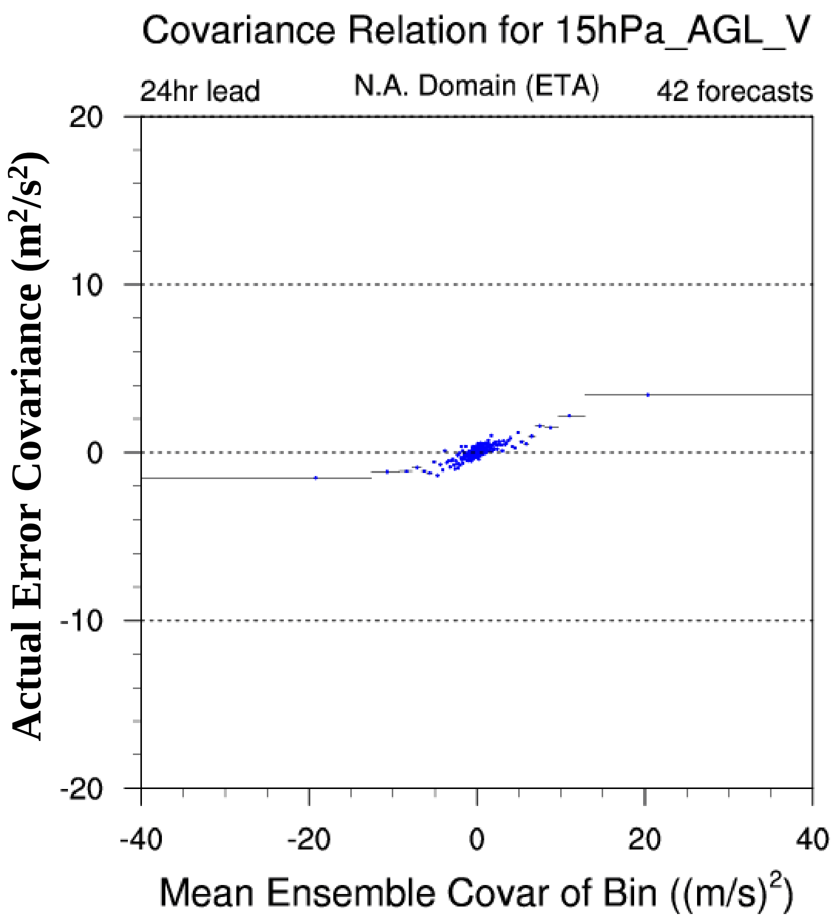




12 Hour Forecast

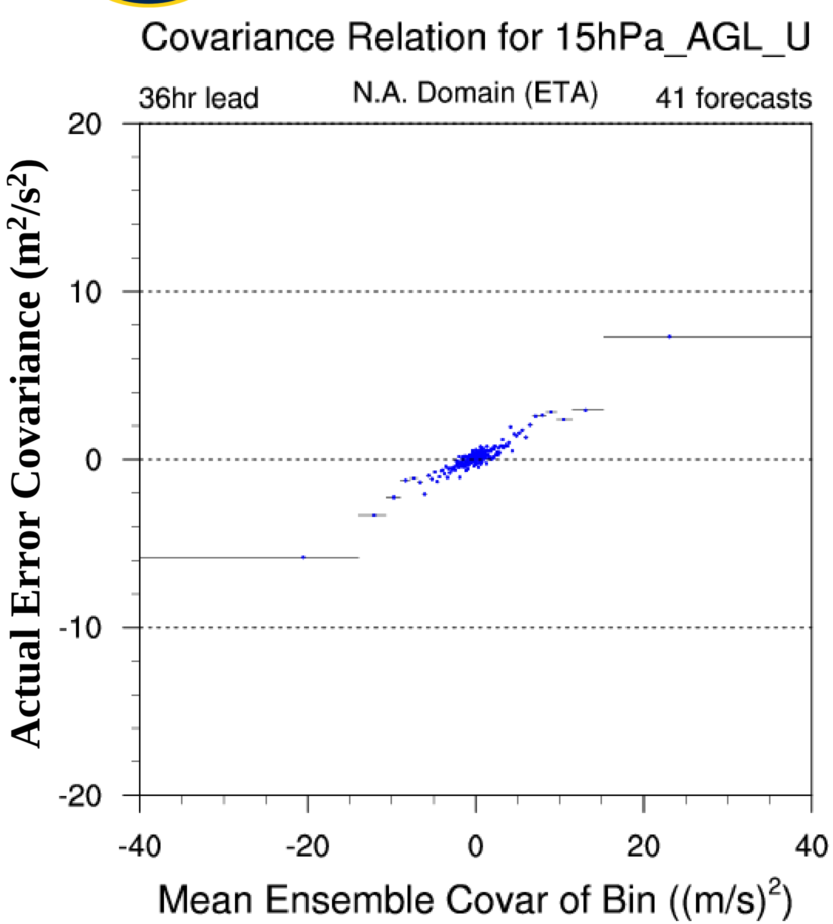
Linear Covariance Calibration - Control

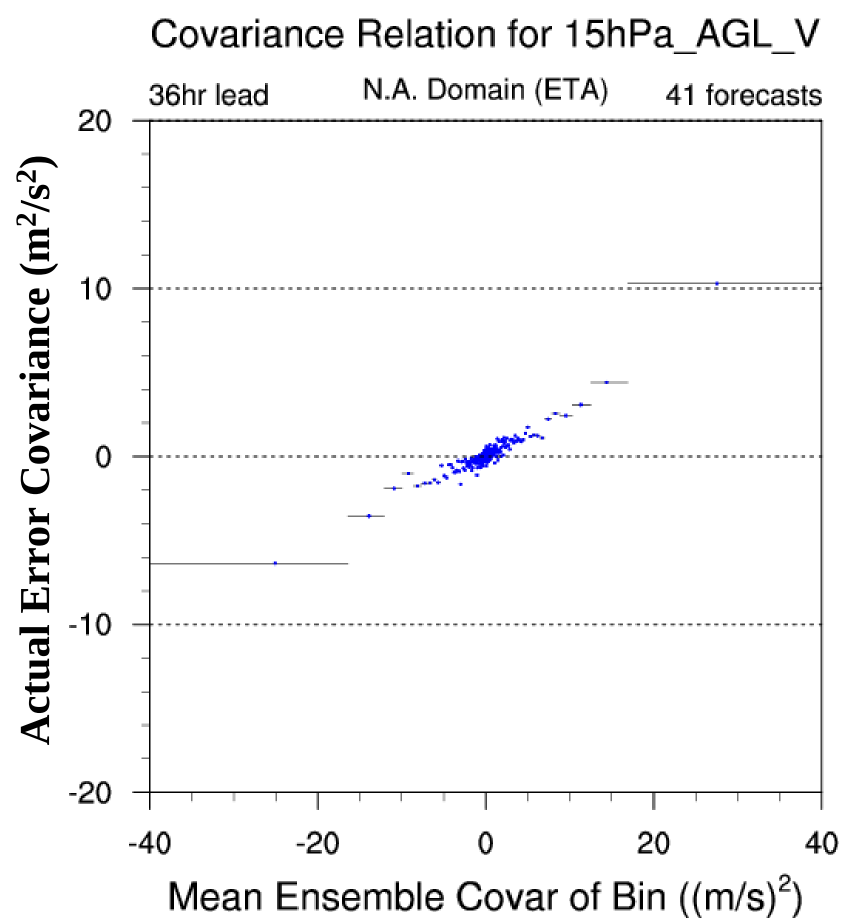




24 Hour Forecast

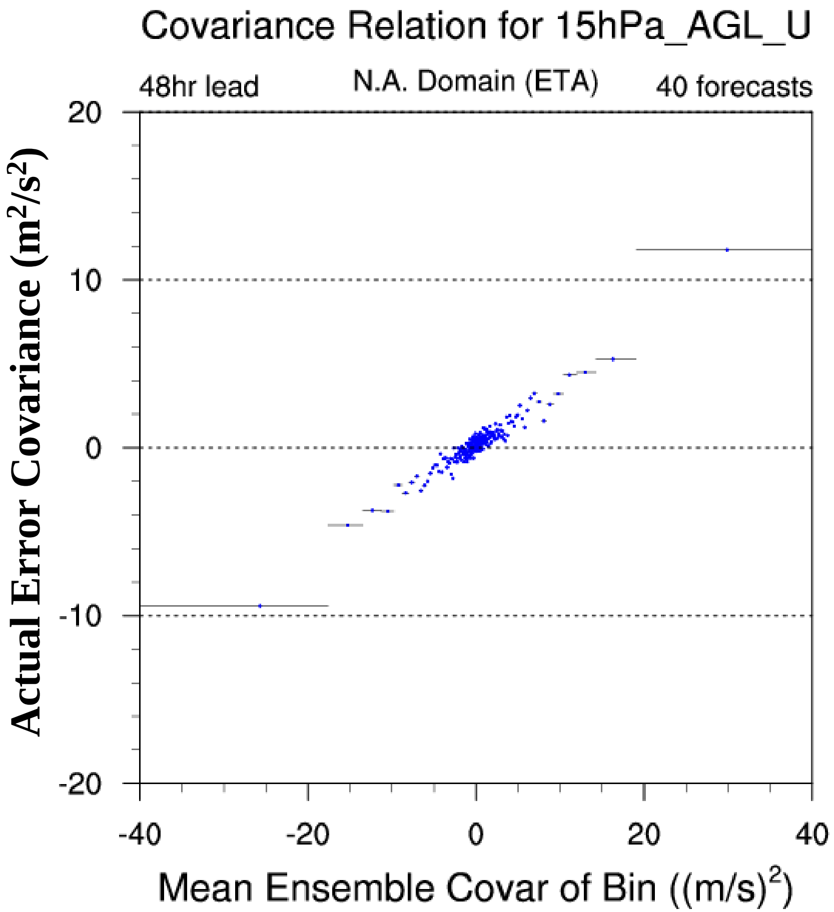
Linear Covariance Calibration - Control

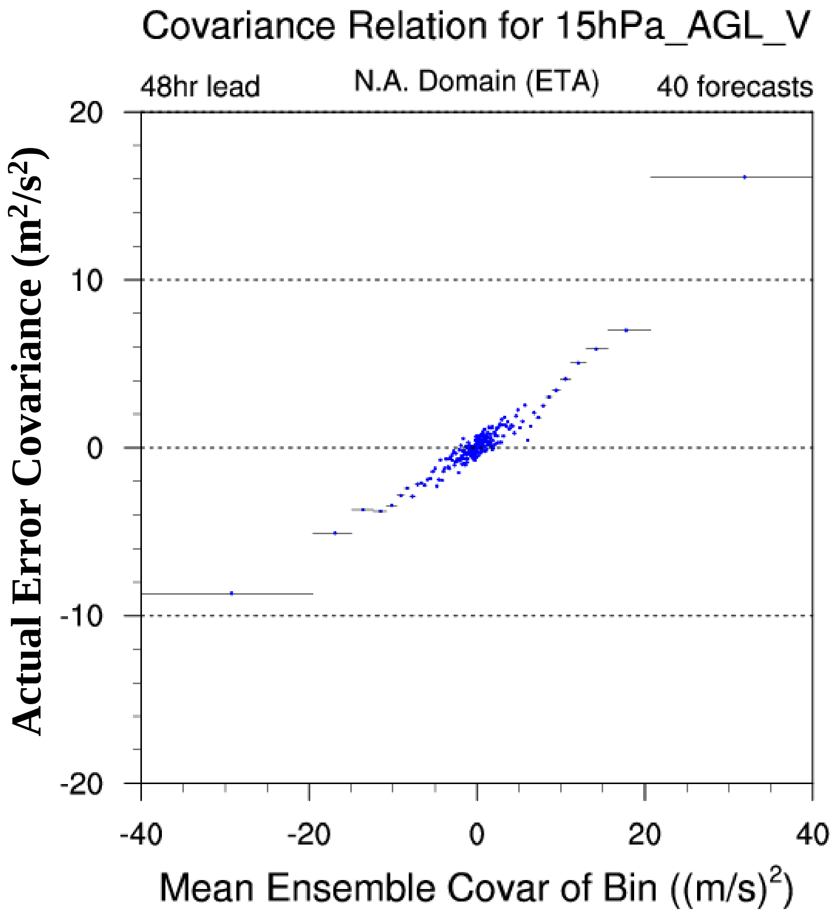




36 Hour Forecast

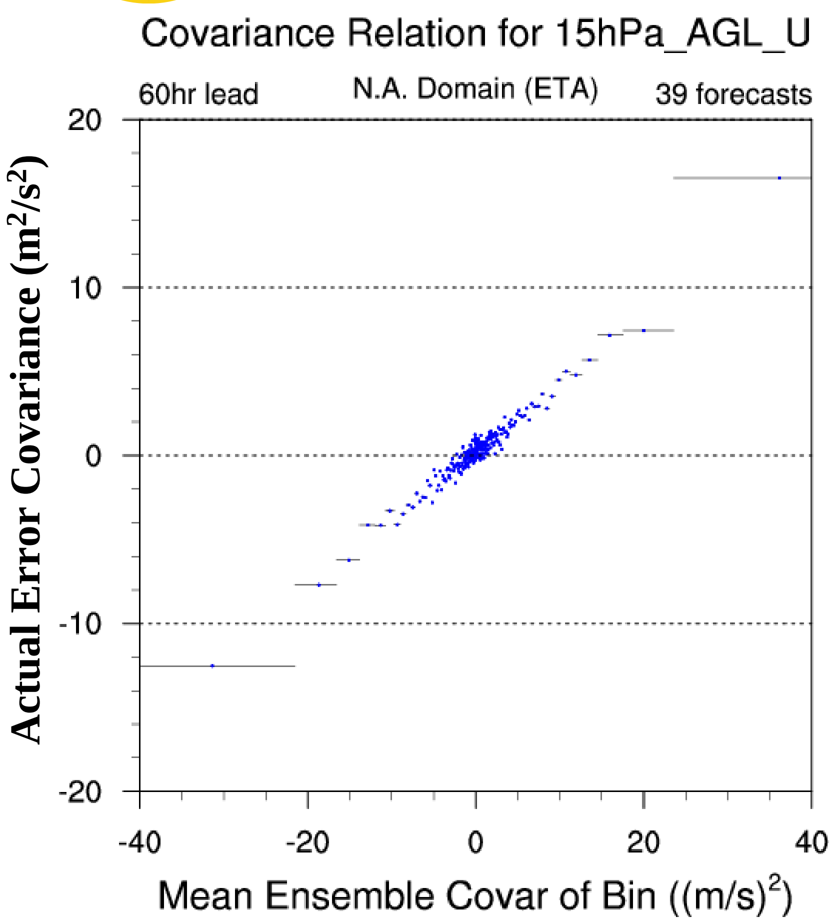
Linear Covariance Calibration - Control

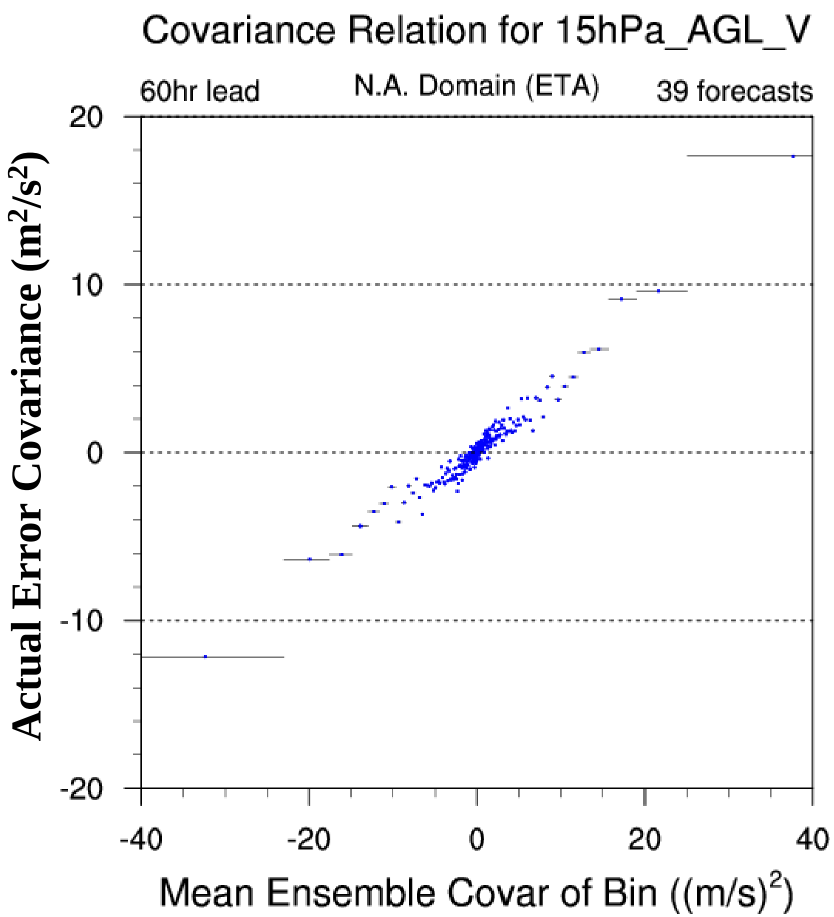




48 Hour Forecast

Linear Covariance Calibration - Control



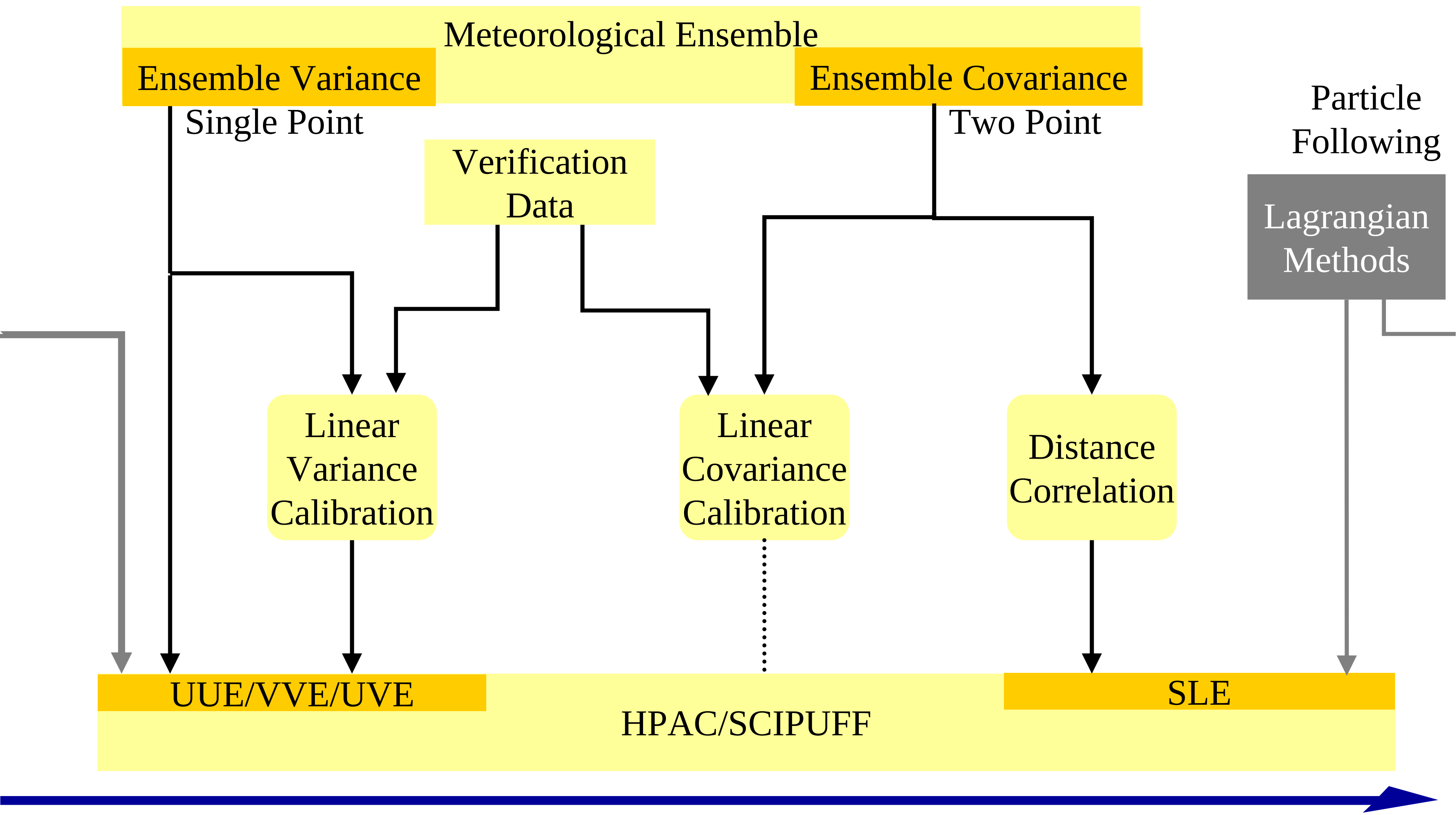


60 Hour Forecast

Linear Covariance Calibration

- Linear Covariance Calibration may work, but there is currently no direct route for ingesting covariance information in SCIPUFF
- However, spatial variability is related to the Lagrangian time scale, so perhaps we could find a way to use covariance information that CAN be used for SCIPUFF…

Relating Correlation and Distance

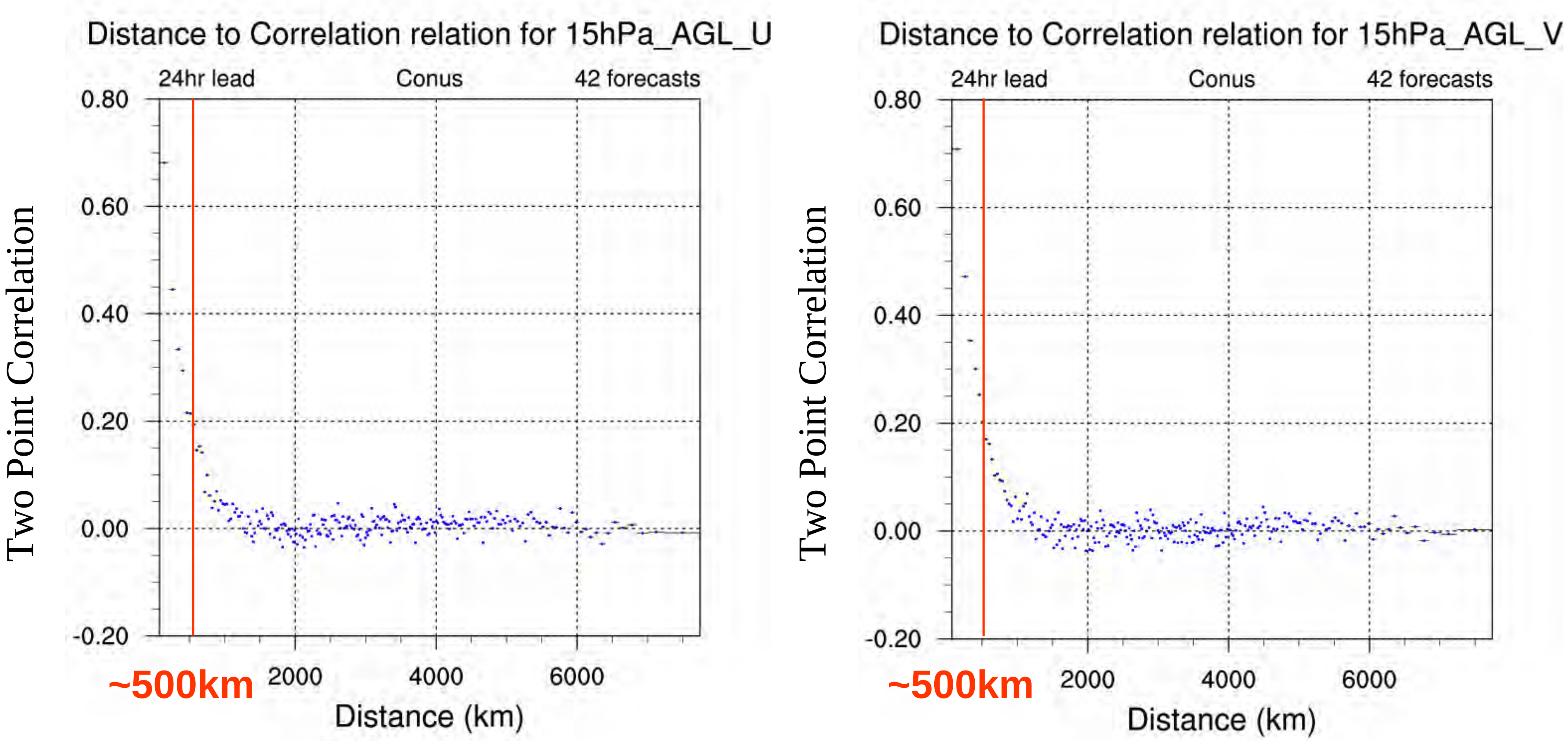


Relating Correlation and Distance

$$Corr(x,y)=\frac{Cov(x,y)}{\sigma_x\sigma_y}$$

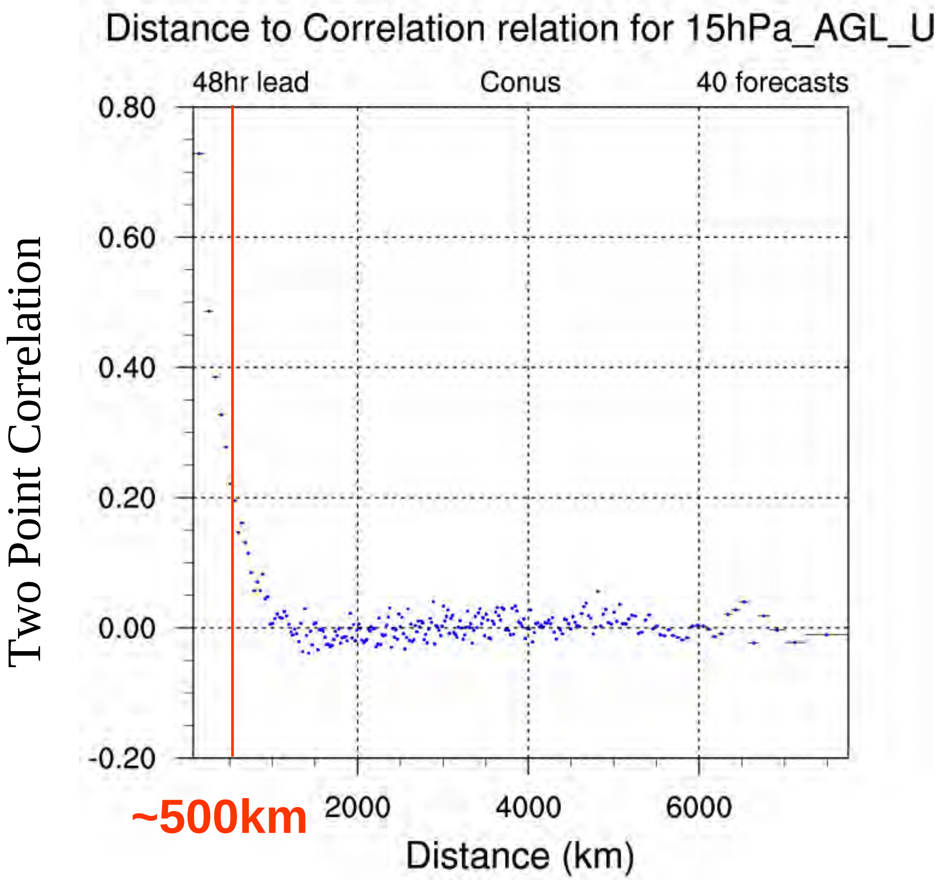
$$ECor\left(s(ij),s(kl)\right)=\frac{ECov(s(ij),s(kl))}{\sqrt{EVar\left(s(ij)\right)}\sqrt{EVar\left(s(kl)\right)}}$$

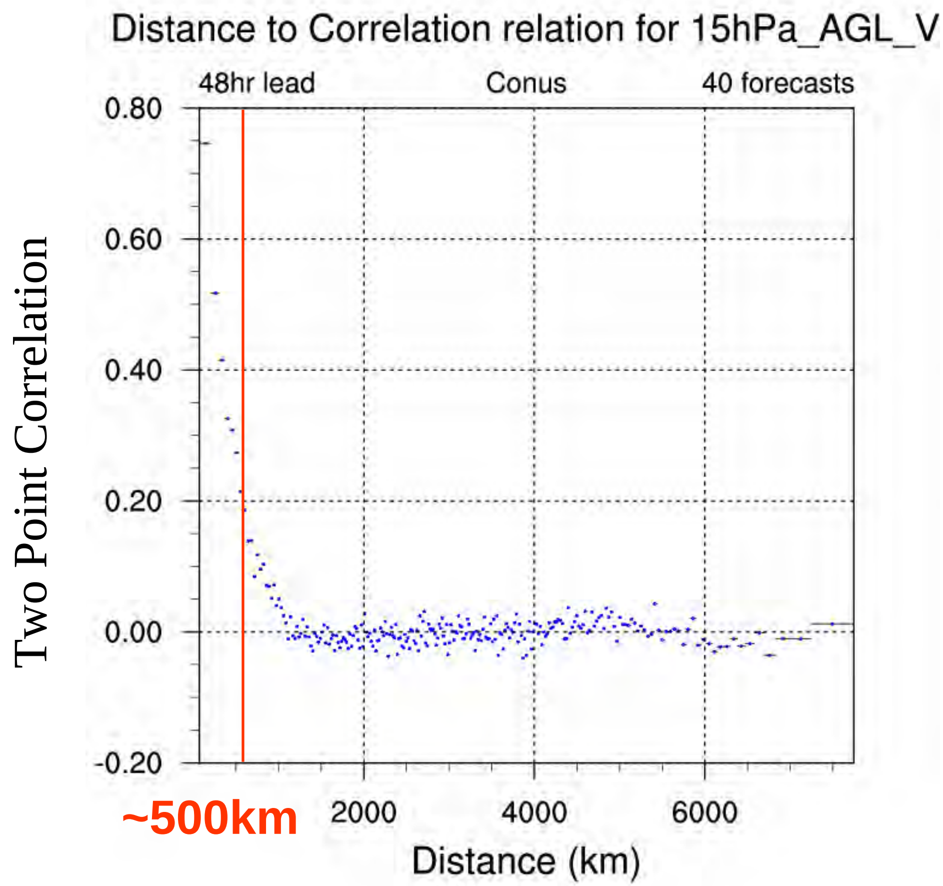
Relating Correlation and Distance



24 Hour Forecast

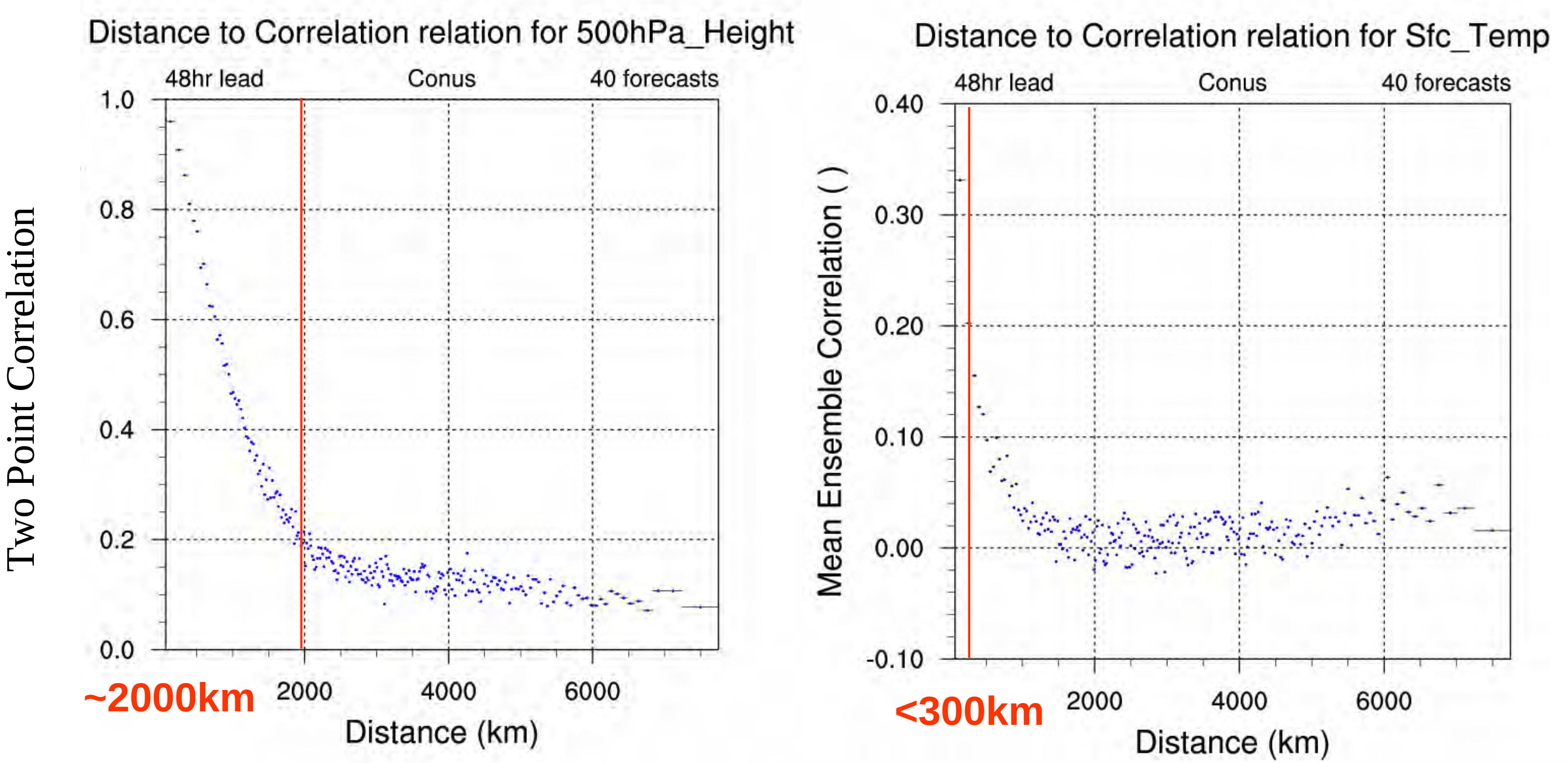
Relating Correlation and Distance



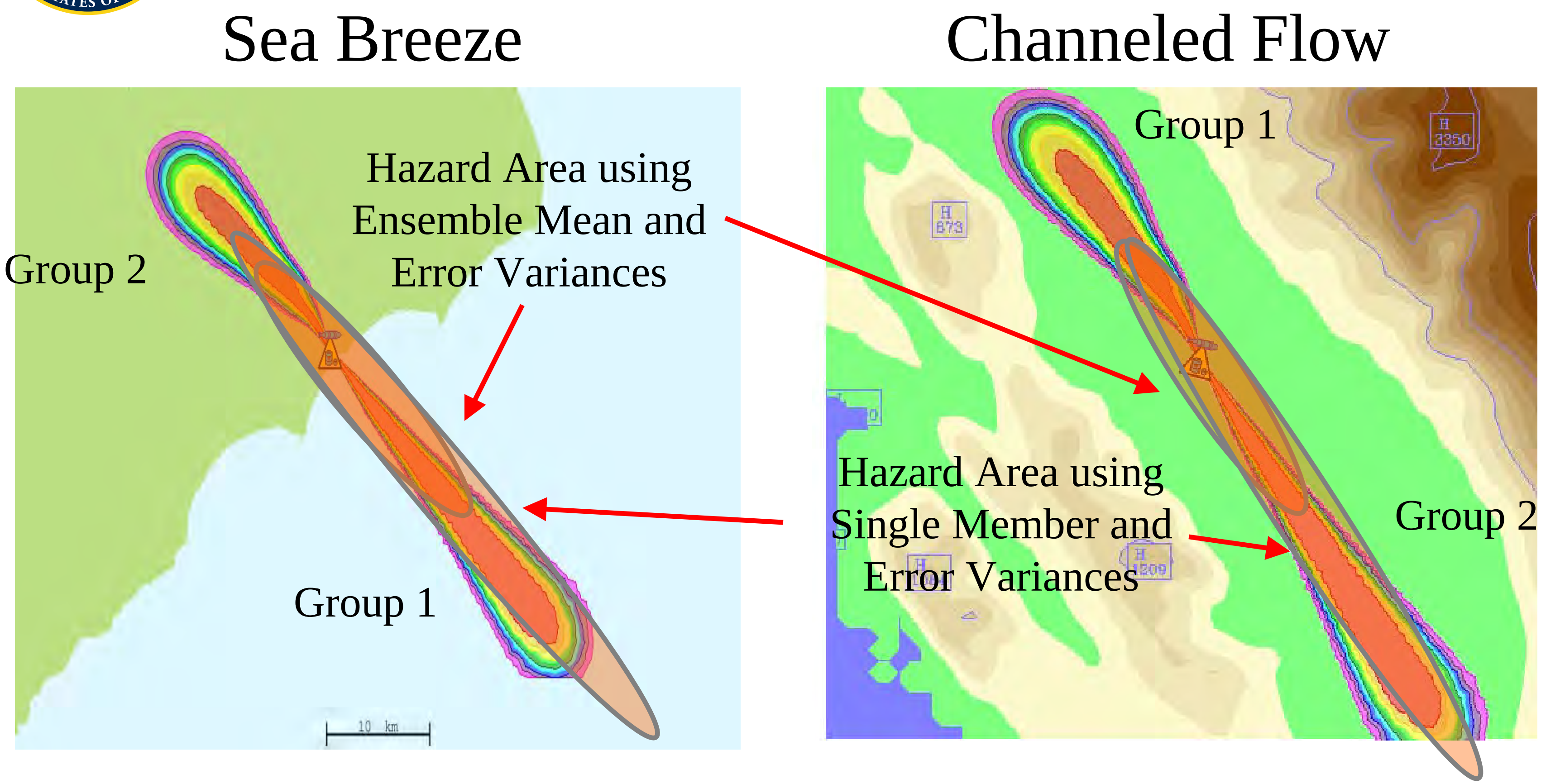


48 Hour Forecast

Relating Correlation and Distance



Limitations of a Single AT&D Run



No amount of broadening of a single plume can accurately predict the shape and extent of the hazard area for these bimodal cases! Covariance information can be combined with an AT&D ensemble to provide a more accurate prediction.

Conclusions

- The Roulston (2005) binning method allows us to recover potentially useful relationships from highly scattered data by binning similar points predictor values.
- When applied to ensemble variances, this method allows us to identify a simple, computationally inexpensive, linear relationship between the ensemble variance and actual variance that can be used to calibrate ensemble output for use in SCIPUFF.
- When applied to ensemble covariances, the binning technique reveals more diffuse and less linear plots, however the actual covariance range is much smaller than the ensemble covariance range. If a control member is used rather than an ensemble mean, a clear linear relation is recovered.
- There is a clear relationship between distance separation and ensemble spread correlation. The exact length scale depends on the correlation value you choose as a cutoff; a 0.2 cut-off yields a distance length of ~500km for 15 hPa AGL winds

Future Work

- Examine the capability of the linear calibration method with an ensemble more tuned for PBL parameters
- Explore dependence (if any) on grid resolution and domain size
- Increase the length of the training period and determine any seasonal divisions needed
- Evaluate the effectiveness for other variables and levels, including p-level vs. σ-level considerations
- Continue investigating the use of covariance/distance binning for calculating SLE
- Test implementation of the calibration by using it to calculate UUE for SCIPUFF and compare to SCIPUFF ensemble

Acknowledgements

- Mark Roulston for stressing the importance of covariance information and of calibration, and starting us down the binning path
- Ian Sykes for many discussions about SCIPUFF parameterizations of uncertainty
- Jeff McQueen et al. at NCEP for full ensemble data from SREF

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CBIS 2007
CB CKB with the GIG

Scott Kothenbeutel, Battelle PM

Moses Kamai, Battelle PI

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CB CKB Overview

Client need addressed:

- Secure on-line common knowledge base of chemical and biological weapon related data, accessible and validated.
- Identification of gaps in CB related data.
- Process to accredit data sources.
- Foster communication within CB community.

Future Potential:

- Baseline system for input into

DTRA Program of Record

Description:

- **C**hemical-**B**iological **C**ommon **K**nowledge **B**ase
- CB CKB is an application and virtual data store that allows users to publish, locate and retrieve relevant CB data, while maintaining stewardship of access and control.
- 3 phases to the project, 1st – implementation planning; **2nd- Pilot system;** 3rd – Secure on-line system.
- **Current effort is 2nd Phase – includes development of a pilot system focusing on M&S resources and locally available data such as CDMD, Agent Fate, ASK.**

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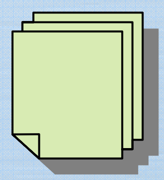
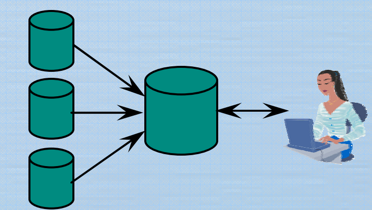
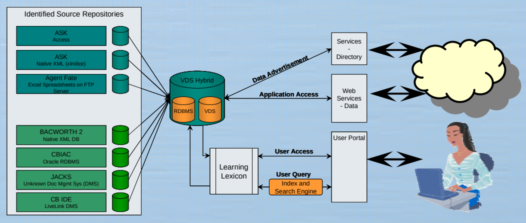
CB CKB Overview

Phase 1	Phase 2	Phase 3
Implementation Plan	***Pilot System***	***Secure On-line CB CKB***
		
May 05 – Jun 06	**Jun 06- May 07**	**Jun 07 – TBD**

The key objectives for this program are:

- Identify and fuse CBIAC and other CB repositories relevant to the CB Community
- Implement and sustain a DoD information assured compliant system
- Implement proven and best practices for the CB Community
- Leverage subject matter experts and available tools to identify and analyze relevant CB data

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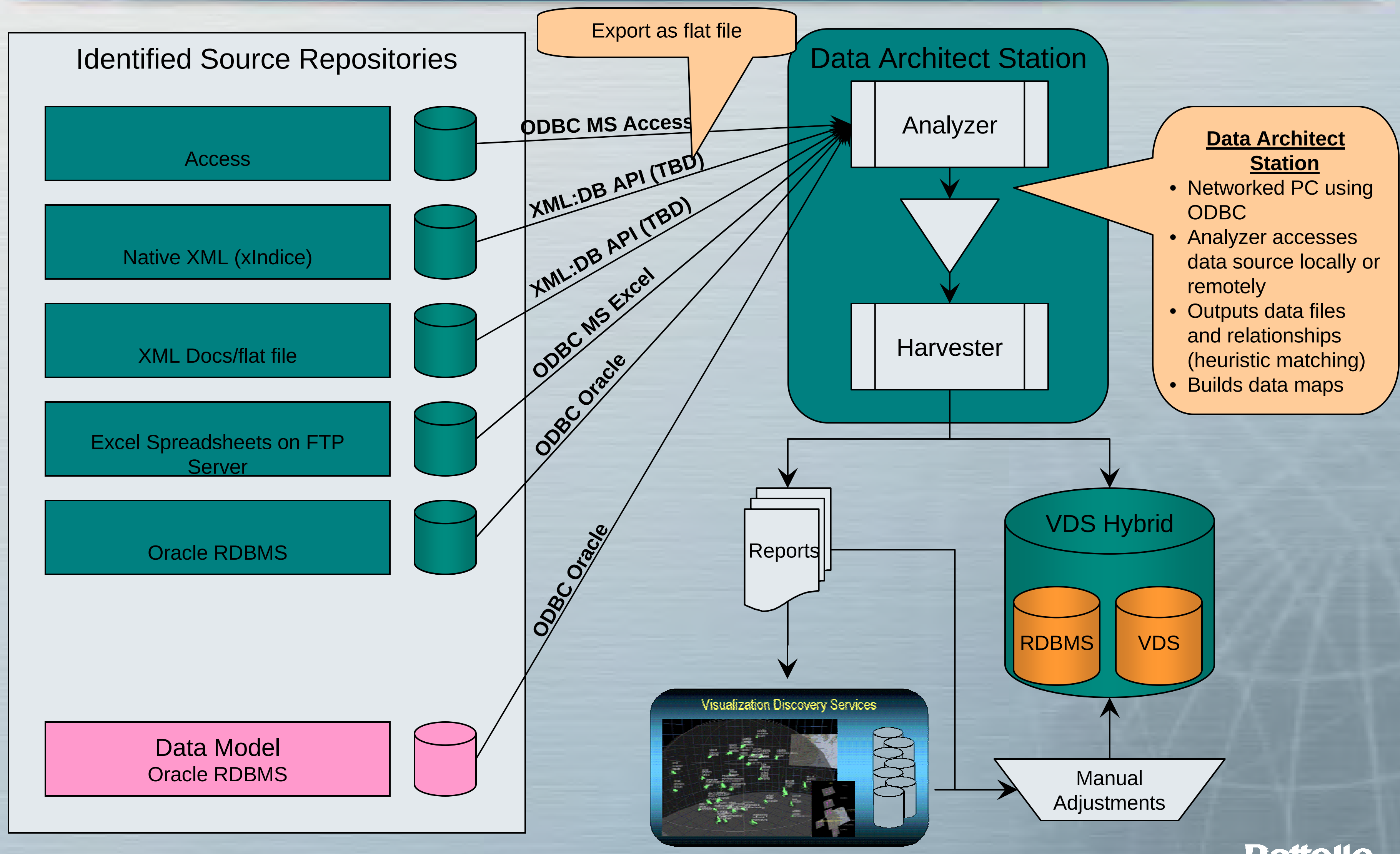
Information Fusion Build Process



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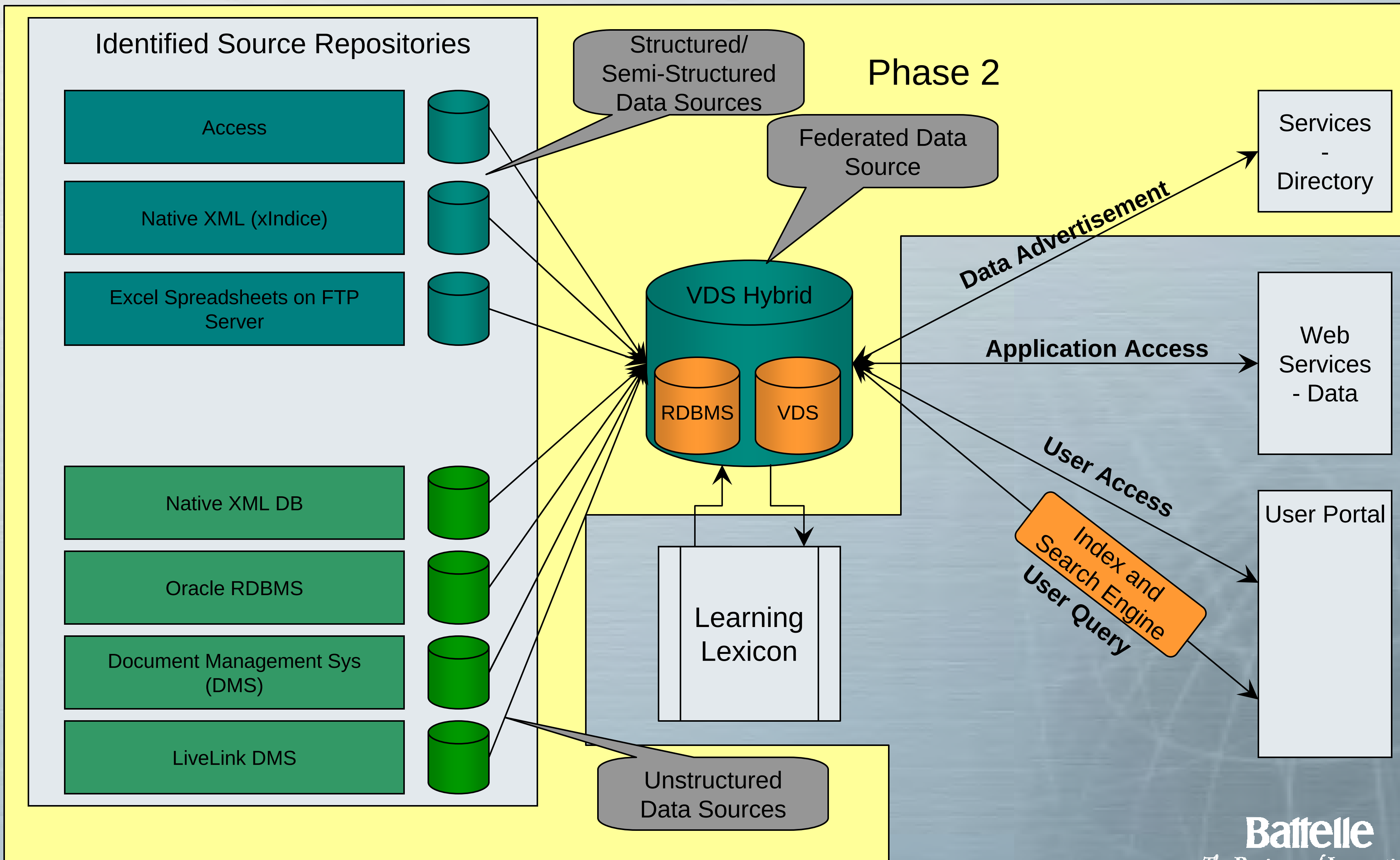
Information Fusion Example



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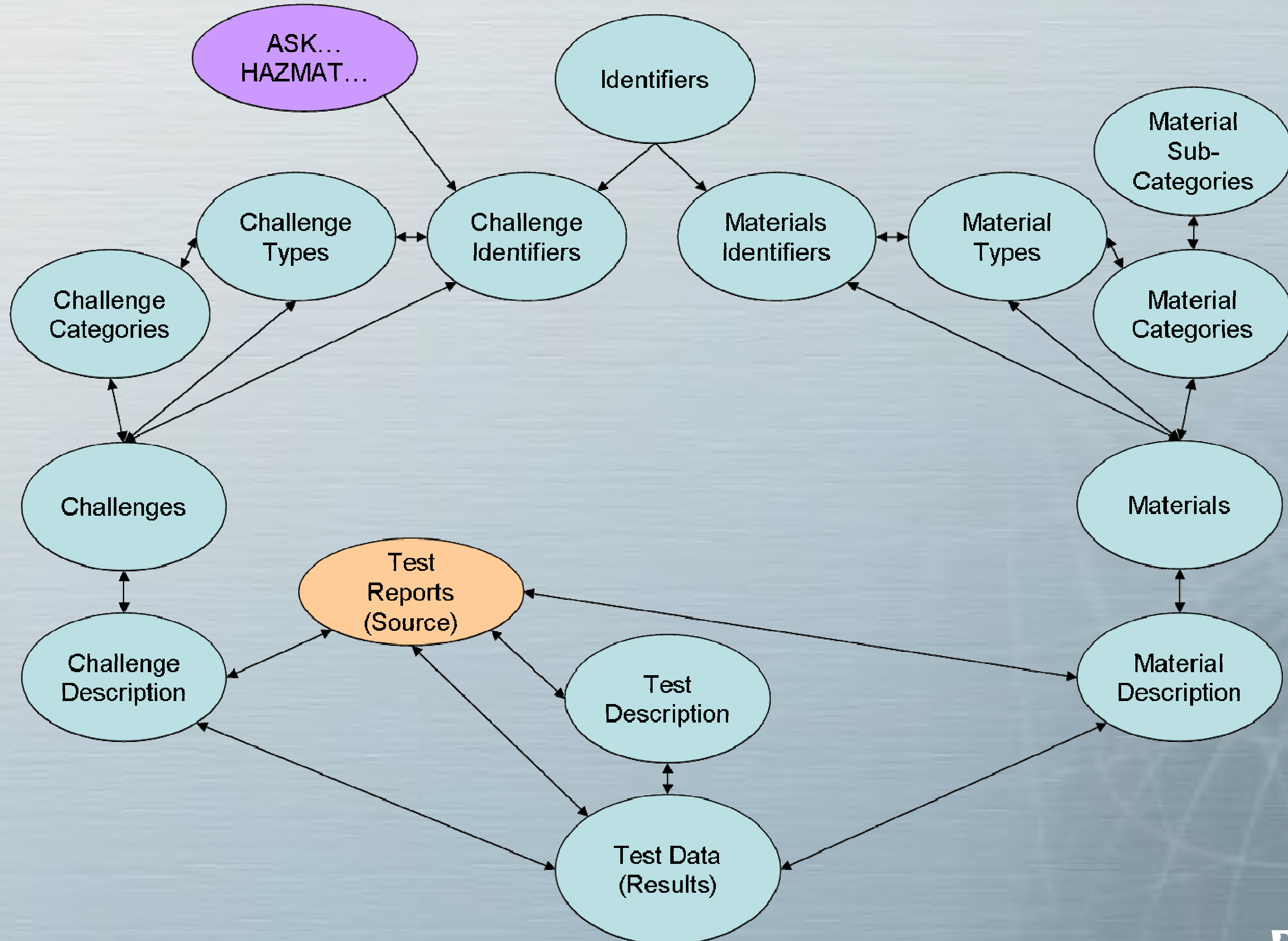
Chemical-Biological Material Effects Database

(CBMED Extract)



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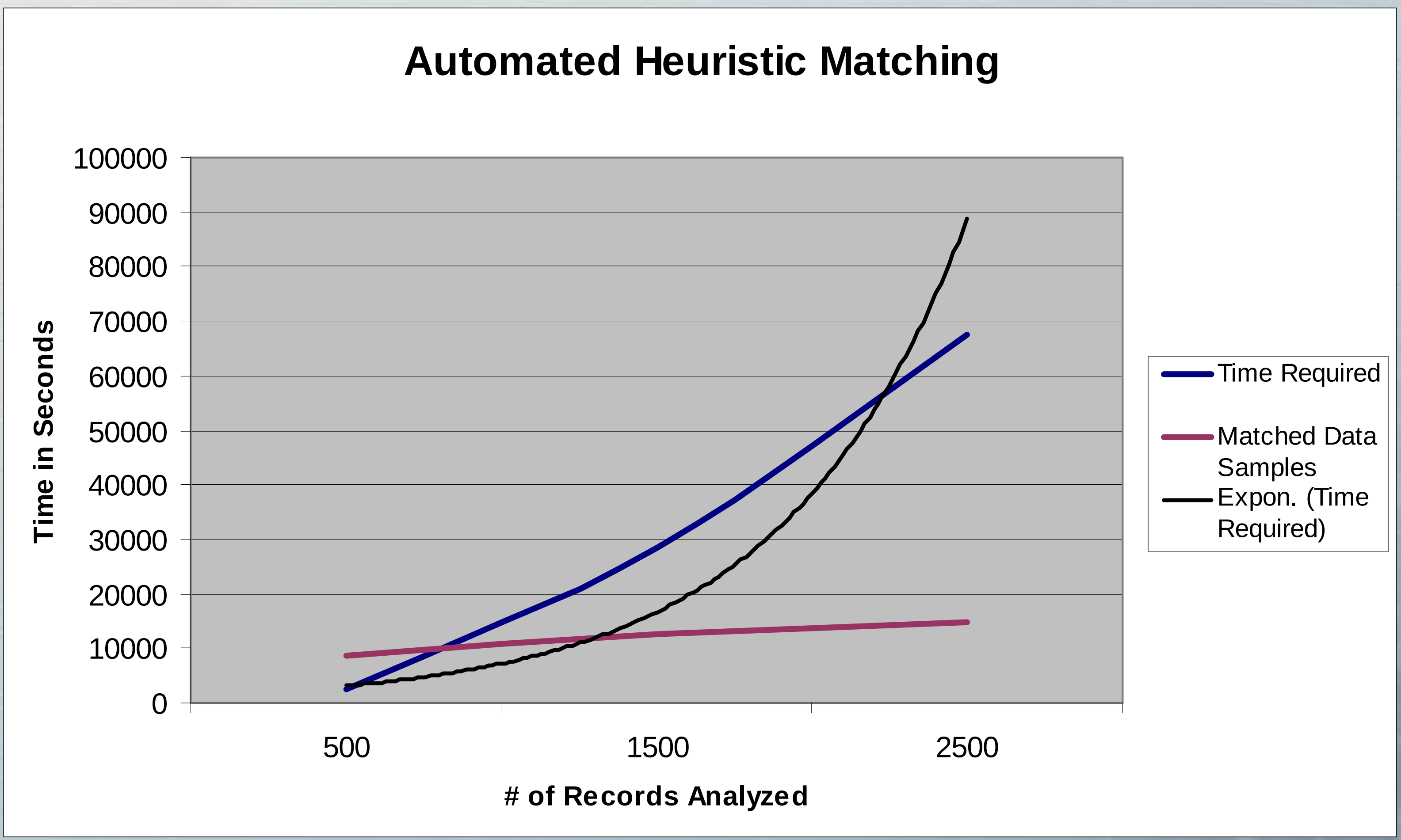
Typical Analyzer Results



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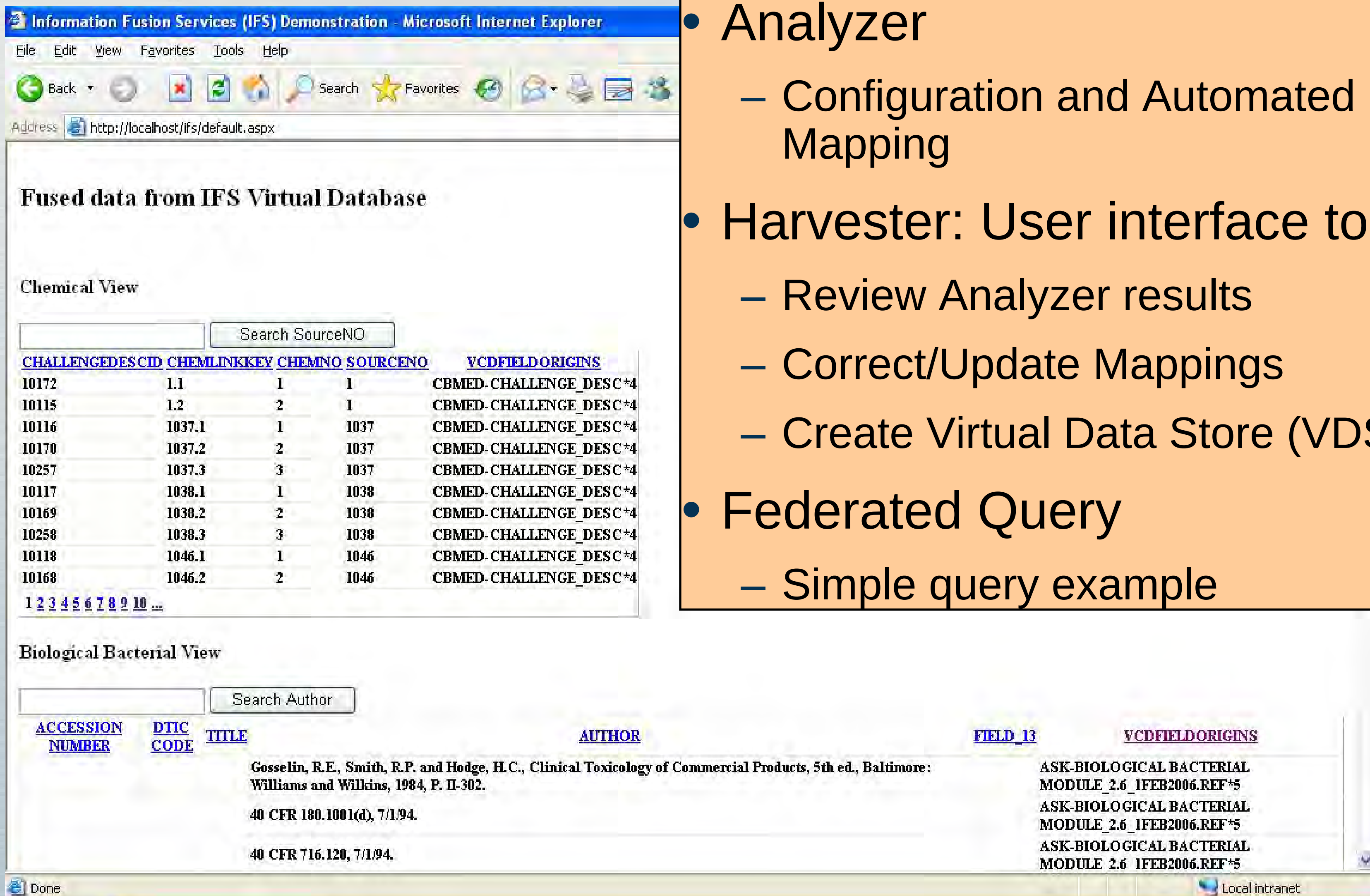
Demonstration



- Analyzer
  - Configuration and Automated Mapping
- Harvester: User interface to
  - Review Analyzer results
  - Correct/Update Mappings
  - Create Virtual Data Store (VDS)
- Federated Query
  - Simple query example

Modelling Medical and Operational Effects of CBRN Usage

Oliver Lanning & Deb Fish

Defence Science and Technology Laboratory, UK

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Introduction

- Decision support tools are developed to predict the effect of CBR events on personnel, equipment and operations
- Tools, such as JOEF and the MOD's Virtual Battlespace, can be used to
    - support the equipment acquisition programme
    - aid pre-operational planning
    - assess the operational implications of concepts, doctrine and technology development
    - guide the research programme
    - aid CBRN training
- This talk will focus on recent work on casualty modelling, quantifying uncertainty and modelling operational effects

What is the Virtual Battlespace?

- A synthetic environment including (some under development)
  - State-of-the-art dispersion models (UDM & SCIPUFF)
  - Models of CBR defence system (detection, protection, MCMs)
  - Representation of movement of entities (aircraft, army units)
  - Links to combat & facility models (WISE, OneSAF, STAFFS)
  - Multiple run controller
  - Wargaming mode

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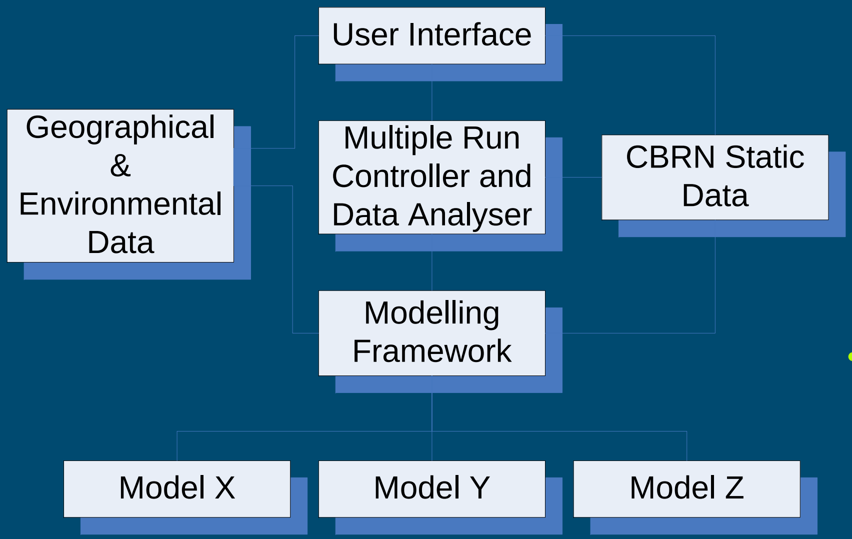
The Virtual Battlespace Models

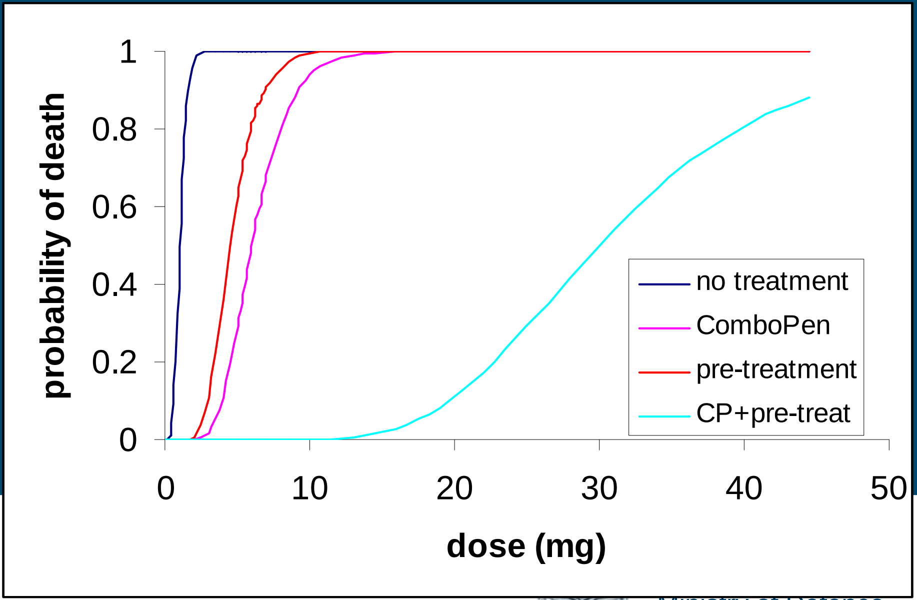
- Dispersion Modelling
  - CBR sources and hazard plumes (weapons, IEDs, RDDs, TICs & TIMs)
  - Urban and Rural (SCIPuff & UDM)
  - Concentration Realisation
- Meteorology
  - Terrain
  - Local Wind Turbulence
  - Sea Breeze



- Military Units/Personnel
  - Effects (casualties)
  - Inhalation & Contact Hazard (liquid pickup)
  - Medical Countermeasures
  - IPE
  - Physiological Burden
  - Aggregation
  - Value of Information
- Detectors
  - Simple (threshold)
  - Generic
  - Specific
  - Standoff
  - Biological Background
  - Single & Network Alarms
- Modes of Use
  - Wargaming
  - Assessment

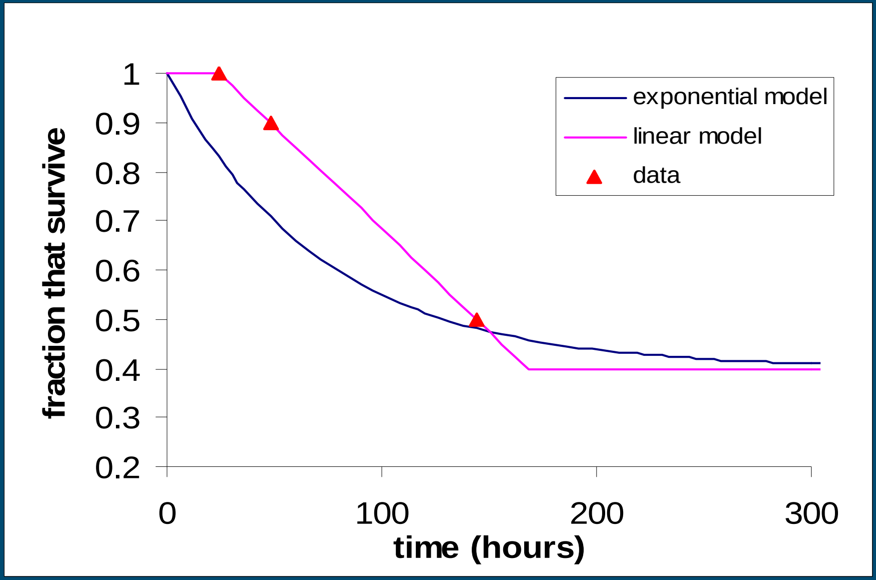
Casualty Modelling

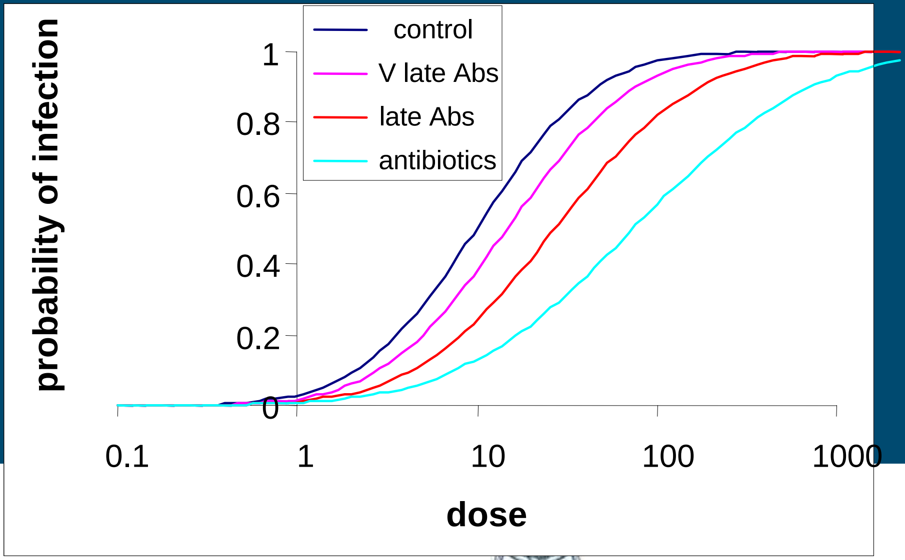
- Modelling physiological effects of a CBR attack or incident is crucial
  - Need to account for both inhalation and percutaneous ingestion of agent
  - Should include individual protection
    - Respirator
    - Suit
  - Predict effects of medical countermeasures
    - Nerve agent treatments
    - Vaccines
    - Antibiotics
    - Antitoxins/Antivirals



Medical Countermeasures (MCMs)

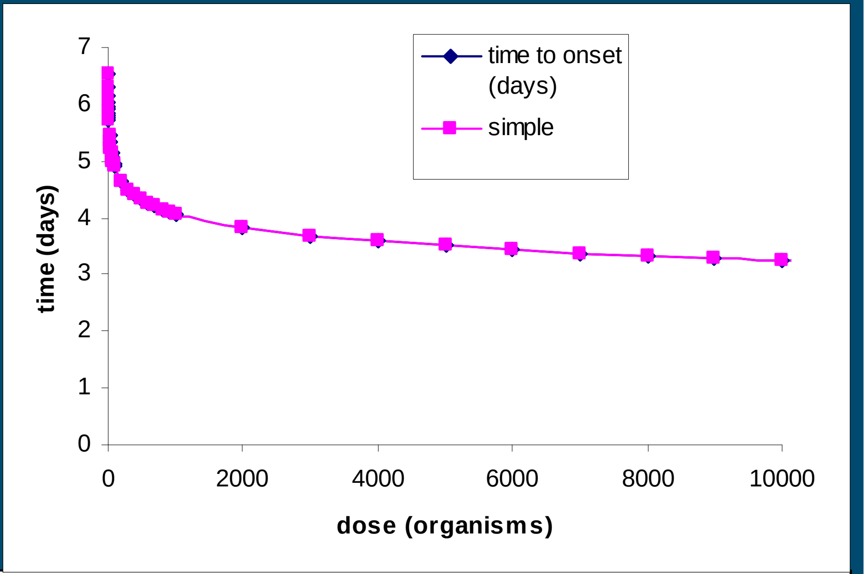
- The time to onset of symptoms is crucial for biological MCMs
  - Symptoms typically present days after exposure
- The efficacy of antibiotics, antivirals and antitoxins are strongly time dependent
- Therefore, the model accounts for the time that these MCMs are administered
  - Window of opportunity
  - Can assess concepts and doctrine and medical response

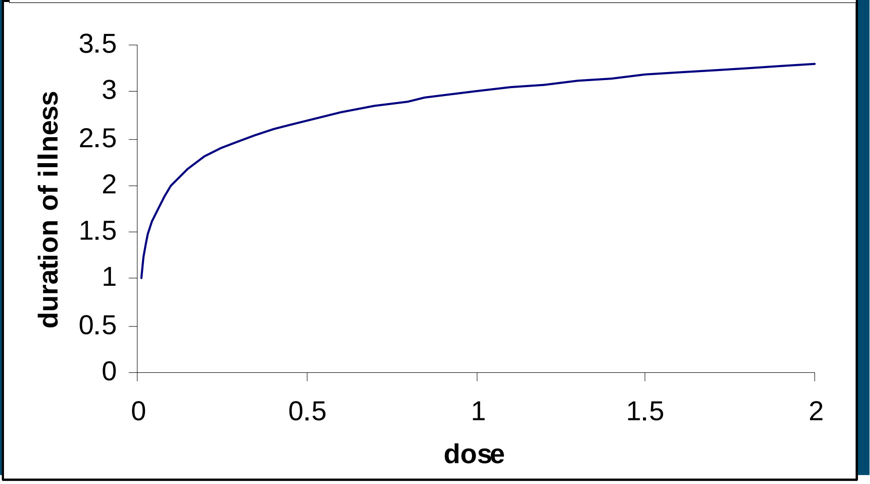




Time to onset and duration of symptoms

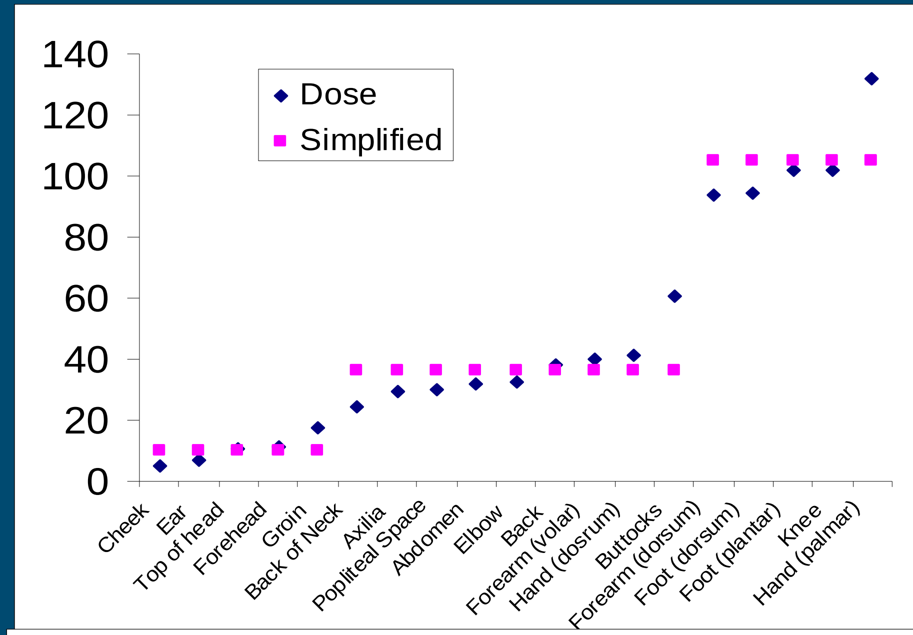
- Modelling the time to onset of symptoms can allow realistic training scenarios to be run
  - Commanders do not discover covert biological release until medical surveillance triggers
  - Speed of response then determines the effectiveness of treatment
  - Allows investigation of effect on operational outcome

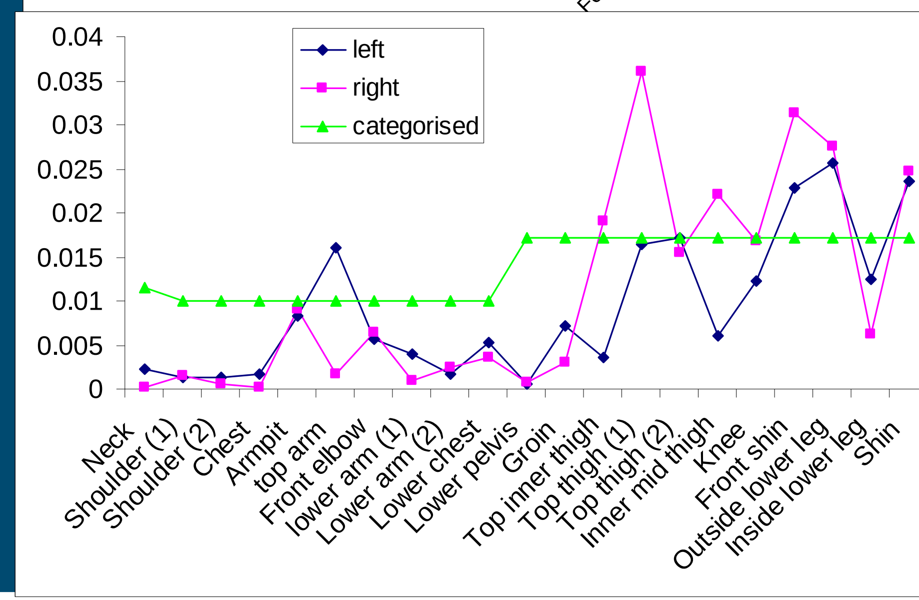




Contact Hazards

- Both liquid and vapour hazards
- Data available from Porton Man
  - Helps drive research on future clothing



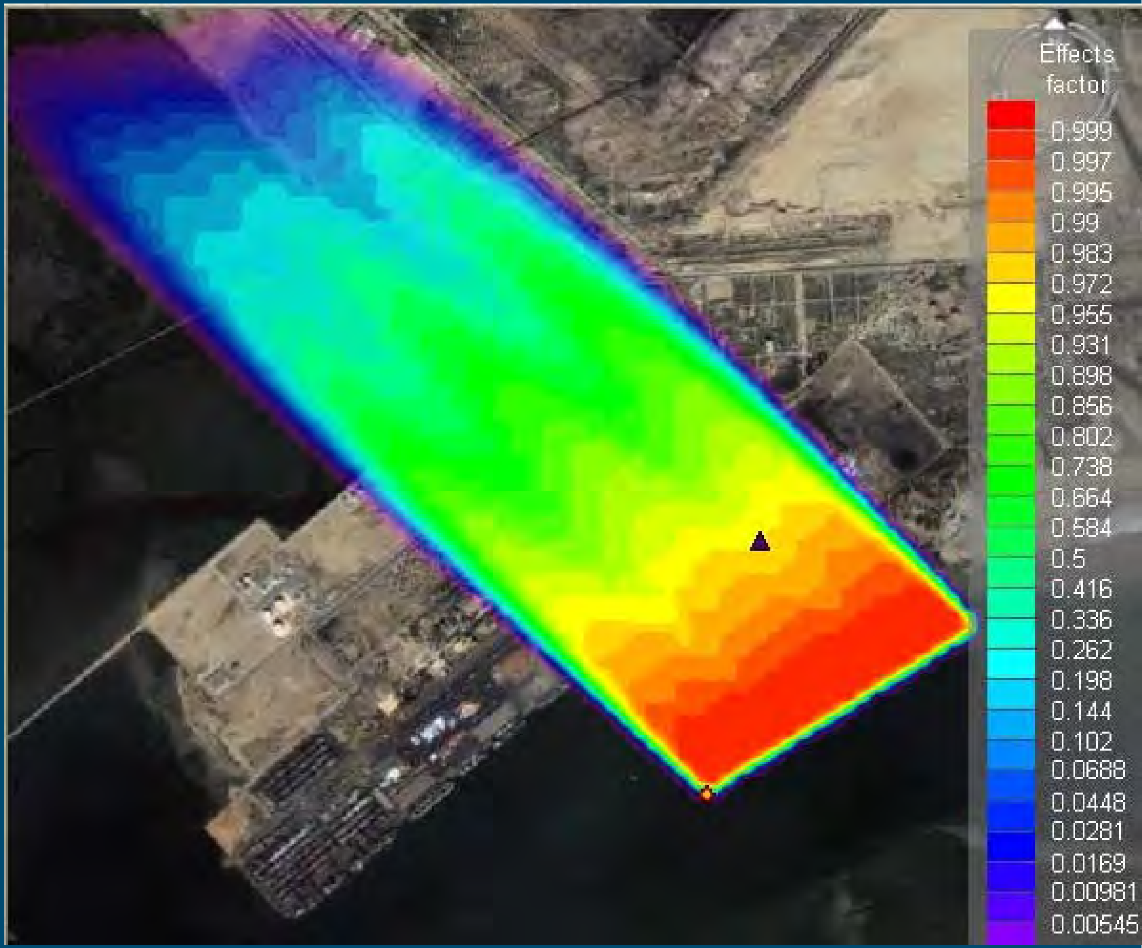


Operational Effects

- The Virtual Battlespace predicts the impact of CBRN on personnel, equipment and terrain
- Drive to determine the effect of CBRN on the operation & campaign
- In general, this will be done by linking or inputting to appropriate high-level modelling tools
  - This can include both simulations and wargames
  - Physical link was investigated to UK WISE (formation level simulation)

Operational Effects

- Initial focus on sea ports
- Using CBR Virtual Battlespace (CBVB) to determine effects of CBR attacks
  - Casualties
  - Contamination
- 17th Port & Maritime Squadron will advise on work arounds
- Quantify effects on logistics chain using the Dstl Marflow model for EDPI



Effect of CBRN on Peace Support

- Aim – to develop capability to use CBVB to quantify effects of CBRN on Peace Support Operations (PSOs)
- Existing Dstl computer assisted wargame PSOM determines outcome of PSO
  - CBVB can determine casualties and contamination as input to PSOM
  - This then impacts on all members of the game
  - Can run scenarios with and without CBRN for comparison

Impact on Operational Outcome

- The Virtual Battlespace will be used to provide input for table top wargames
- Model dispersion of covert biological attack
  - Casualty chain will provide time to onset of symptoms for all exposed individuals
  - Commander will start to see units report illness
  - Medical response determines combat effectiveness

Conclusions

- A new casualty model chain has been developed
  - This accounts for
    - Respirator and suit
    - Medical countermeasures
    - Time to onset of symptoms and efficacy of MCMs
- The casualty models allow, in combination with other tools, for the operational effects of CBRN to be determined
- This provides invaluable pre-operational planning and training opportunities

Decision Support using Mission Simulation and Modeling Tools

10 January 2007

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This work was sponsored by the Defense Threat Reduction Agency under Air Force Contract FA8721-05-C-0002. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the United States Government.

Study Objectives

- **Provide tools to support mission model application**
  - **Model agnostic to extent possible**
  - **Guide data gathering and input scenario definition**
  - ***Eventual Goal: Integration with JOEF (Joint Operational Effects Federation)***
- **Explore suitable mathematical approaches**
  - **Statistical tools for experimental design**
  - **Mathematical/statistical methods for results analysis**
  - ***Eventual Goal: Automated optimization of alternatives***

Study Context

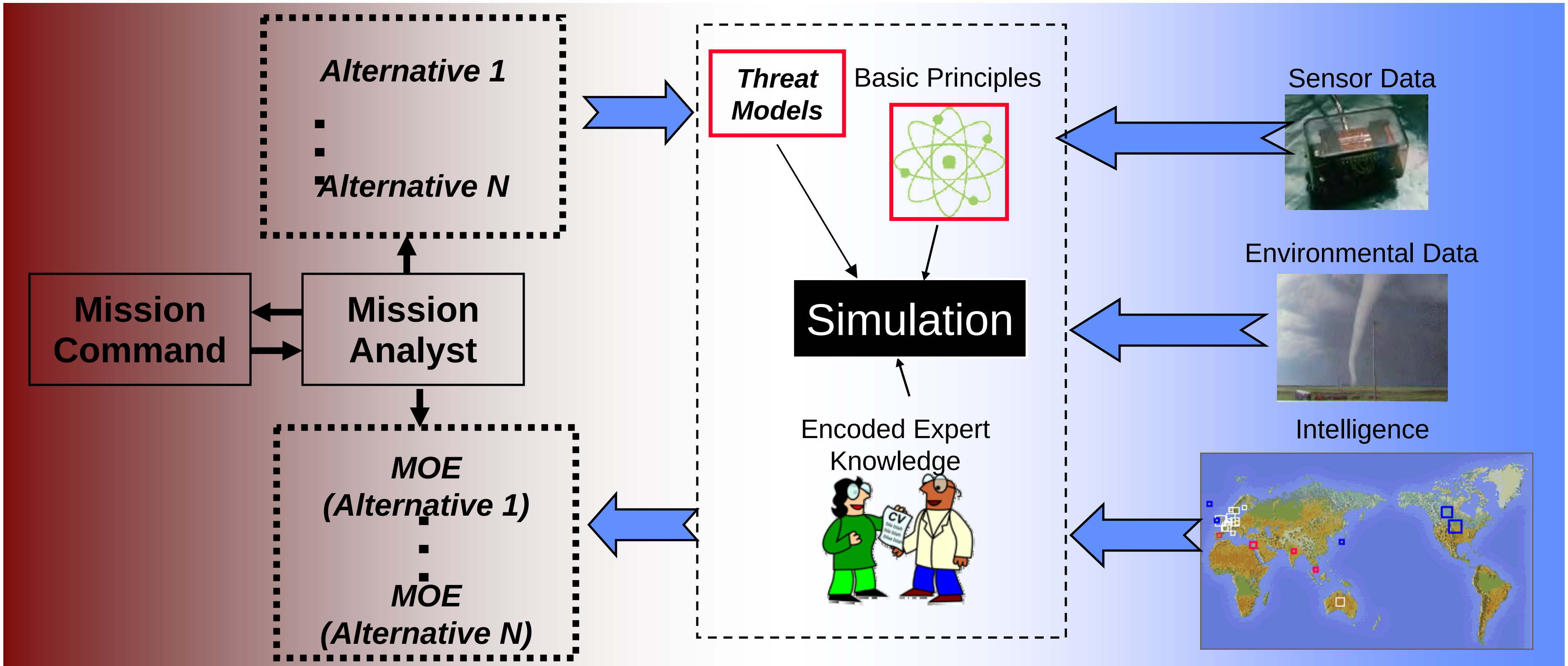
- CB Protection requires complex decisions, e.g.,
  - Placement of critical assets
  - Deployment of sensors
  - Policy regarding MOPP usage

- JOEF contains a sophisticated Discrete Event Simulation model for CB effects on military missions
  - Application to many practical situations may be complex due to detailed simulation processes
    - Rapid data acquisition may be difficult
    - Definition of appropriate scenario set may not be apparent

- Analysts may sometimes lack resources to apply JOEF simulation applications efficiently
  - Complex questions requiring numerous runs
  - Inability to obtain sufficient, accurate data
  - Short time to implement (Order of 1-2 weeks <u>at most</u>)

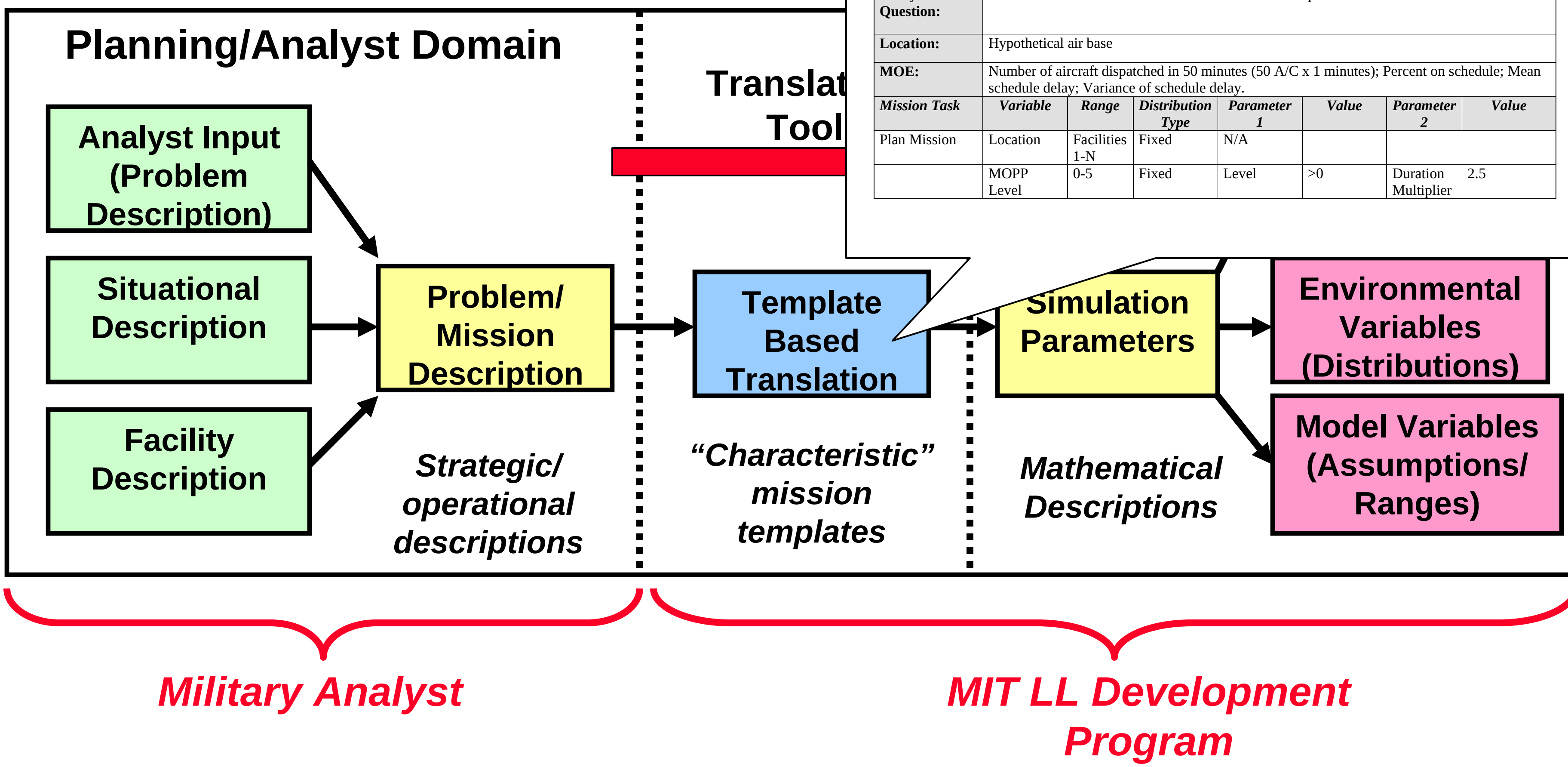
Simulation as Complex Decision Support

- Simulation predicts critical MOE under scenarios reflecting mission goals
- MOE comparisons drive decision outcome
- Large numbers of variables, scenarios and limited time are critical challenges
- Efficient “experiment” design may allow more effective/complete simulation by reducing number of combinations required



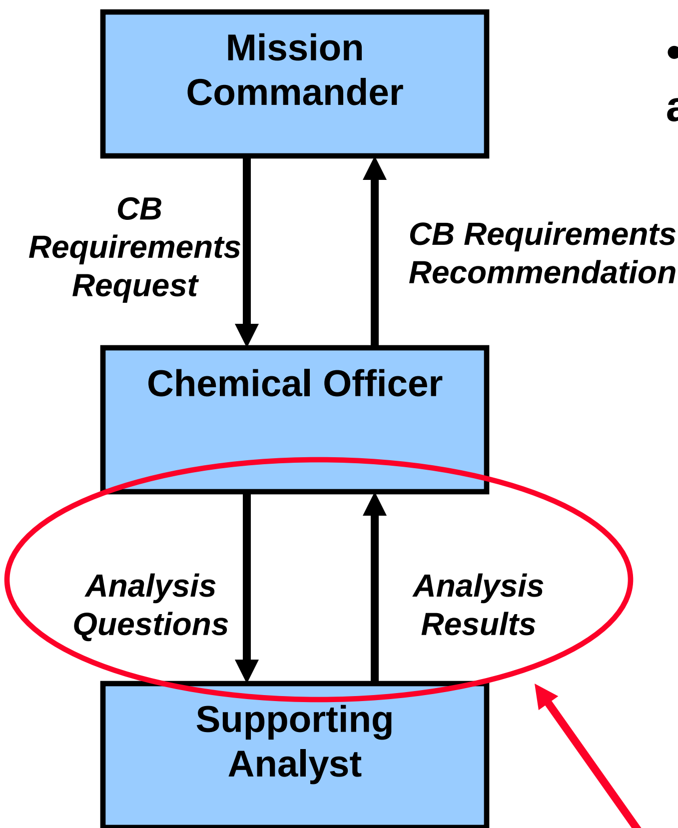
Mission Scenar

Scenario Template: Control Variables							
Scenario Name:	Illustrative Air Sortie Generation – Fighter Aircraft						
Mission Description:	Dispatch a series of 12 fighter aircraft at two minute intervals beginning at approximately 24 hours after receipt of task order.						
Analysis Question:	Under what circumstances would it be beneficial to require staff to wear full MOPP?						
Location:	Hypothetical air base						
MOE:	Number of aircraft dispatched in 50 minutes (50 A/C x 1 minutes); Percent on schedule; Mean schedule delay; Variance of schedule delay.						
Mission Task	***Variable***	***Range***	***Distribution Type***	***Parameter 1***	***Value***	***Parameter 2***	***Value***
Plan Mission	Location	Facilities 1-N	Fixed	N/A			
	MOPP Level	0-5	Fixed	Level	>0	Duration Multiplier	2.5



- **Templates to be developed by user interaction**
  - **Interviews with candidate users**
  - **Specified as "templates" of typical model applications**

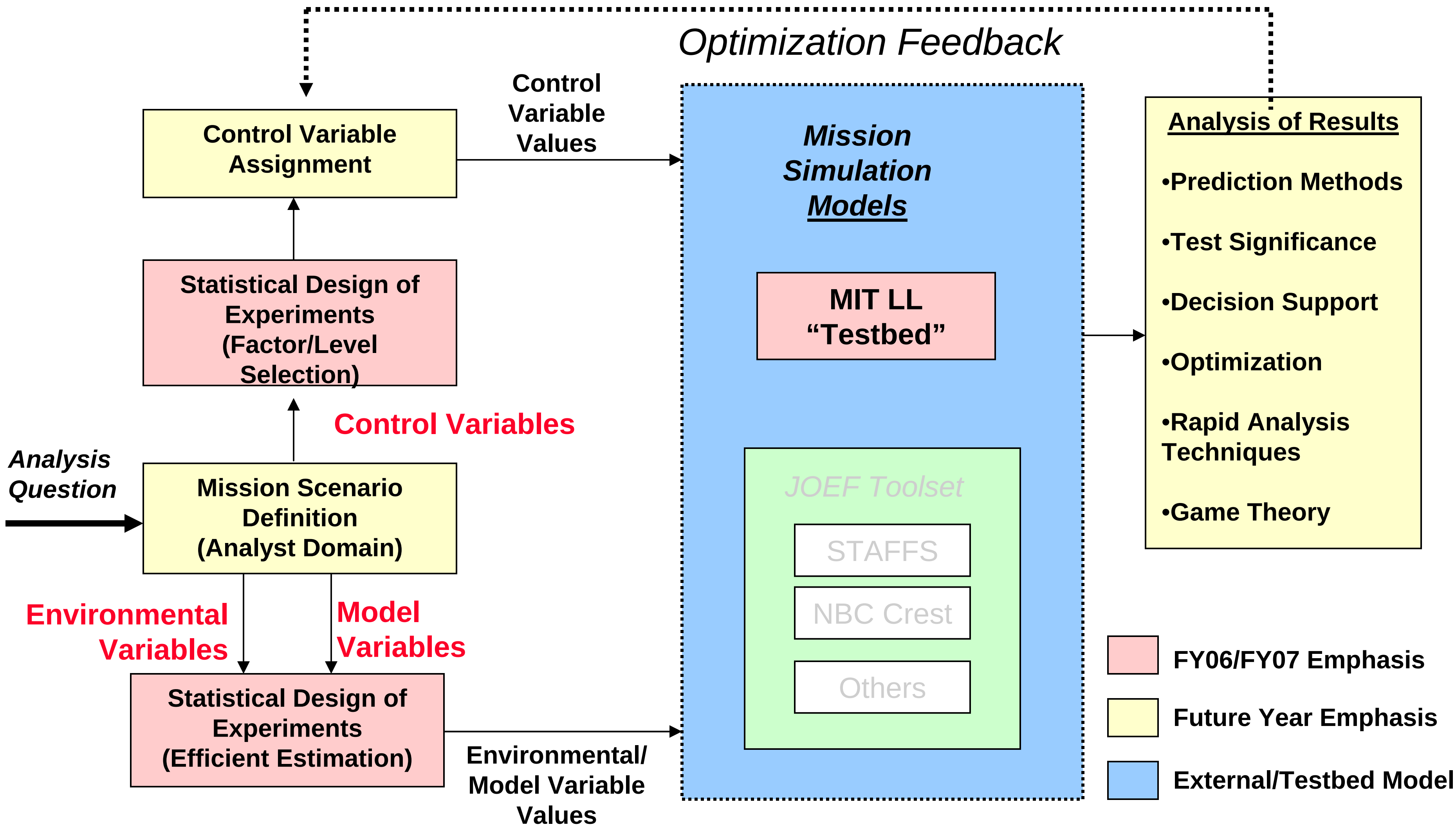
CB Decision Flow



- Requires input regarding appropriate CB protection measures
- Responsible for recommendations on CB Protection
- Responsible for analysis to support recommendations → *Direct beneficiary of simulation tools*

Focus of Mission Templates

MIMIC* System Concept



* Mission Impact Model for Incident Characterization

Statistical Design of Experiments

- **Mathematical techniques to enhance experimental efficiency**
  - Represents "Gold-standard" for testing cause and effect relationships
  - Reduces required number of experiments
    - Grows rapidly with number of variable/levels
    - Just 10 variables at 2 levels requires ~1000 tests to explore effects fully
  - Controls loss of information
    - Reduces number of experiments
    - Provides prior knowledge and selection of information loss

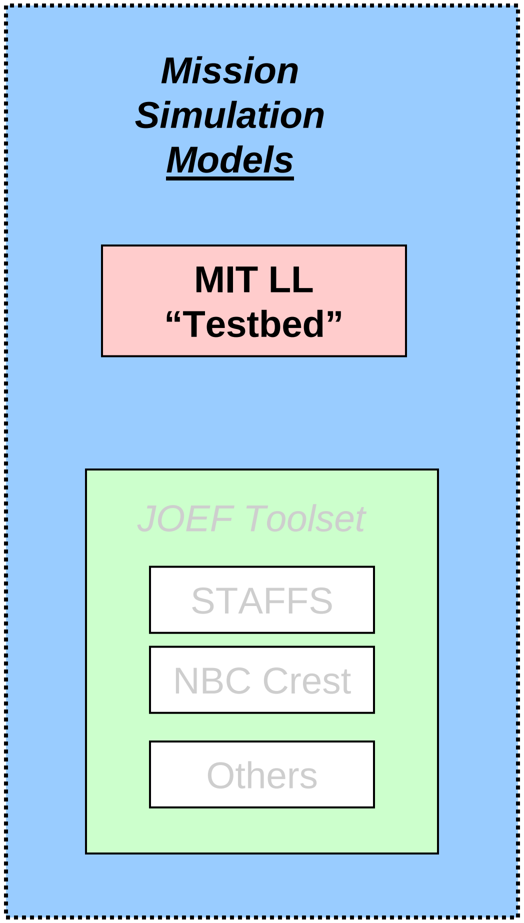
- **Widely applied in numerous applications**
  - Industrial experiments
  - Laboratory experiments
  - Medical trials
  - Agricultural
  - Software validation testing

- **Application to simulation input designs is relatively recent theory**
  - Most literature within past decade

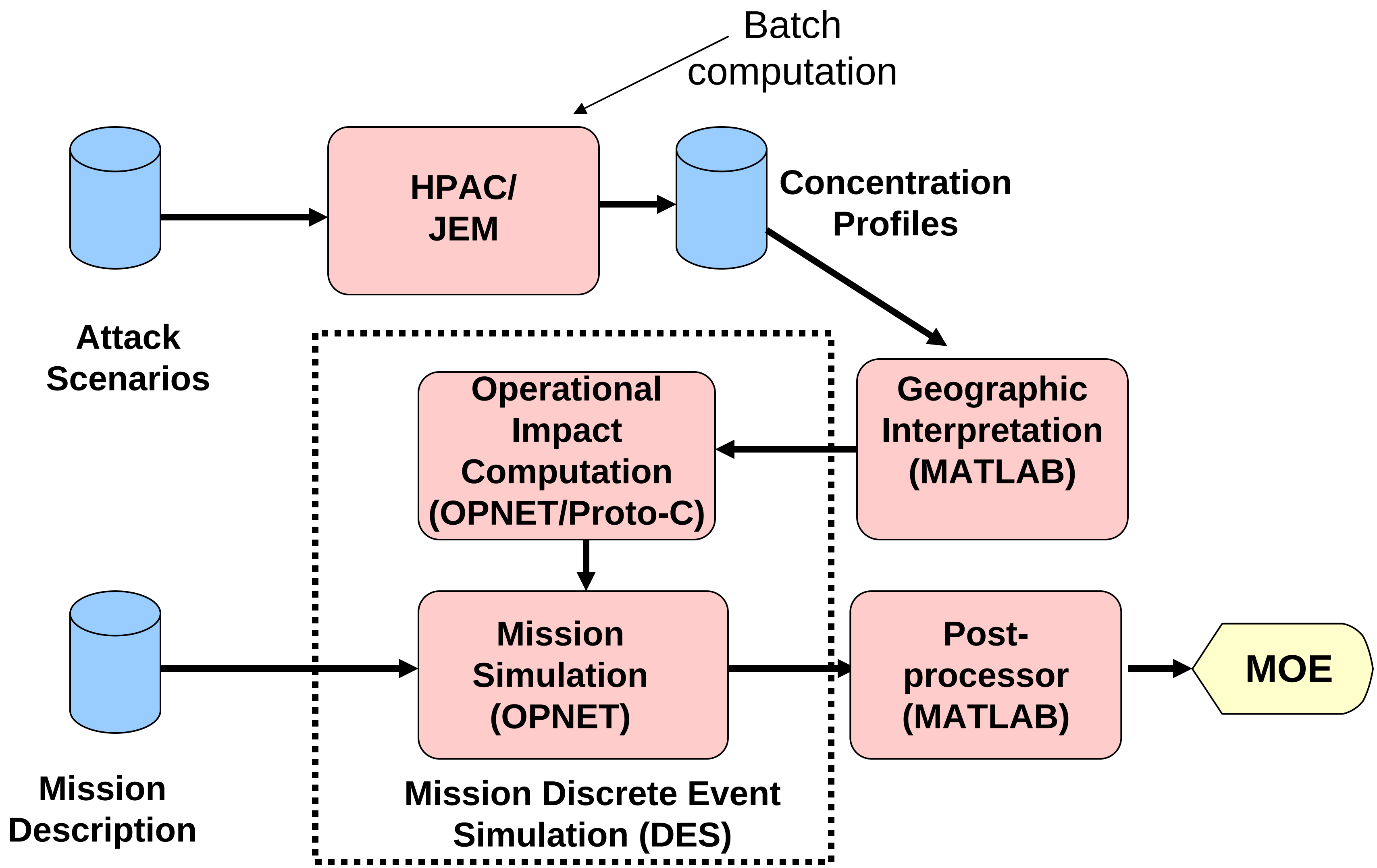
MIT LL Testbed

- **Simple simulation model**
  - Applied as surrogate for more sophisticated tools during development
  - Interfaced to existing hazard model (HPAC/JEM)

- **Illustrative mission is aircraft sortie generation**
  - Major steps to dispatch aircraft
  - Rough parameter estimates (accuracy not necessary for developmental purposes)



MIT LL Testbed Architecture

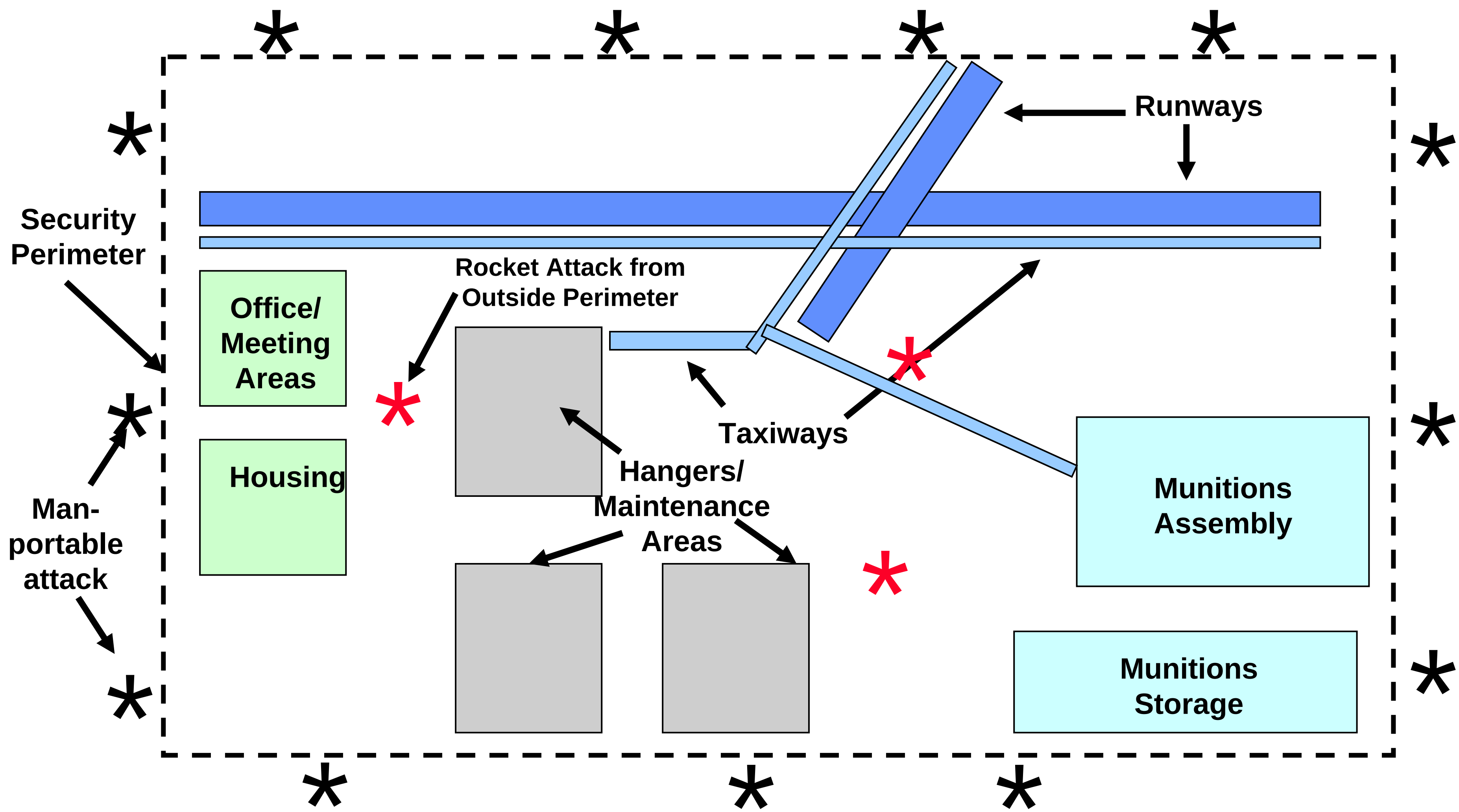


Initial Mission Simulation

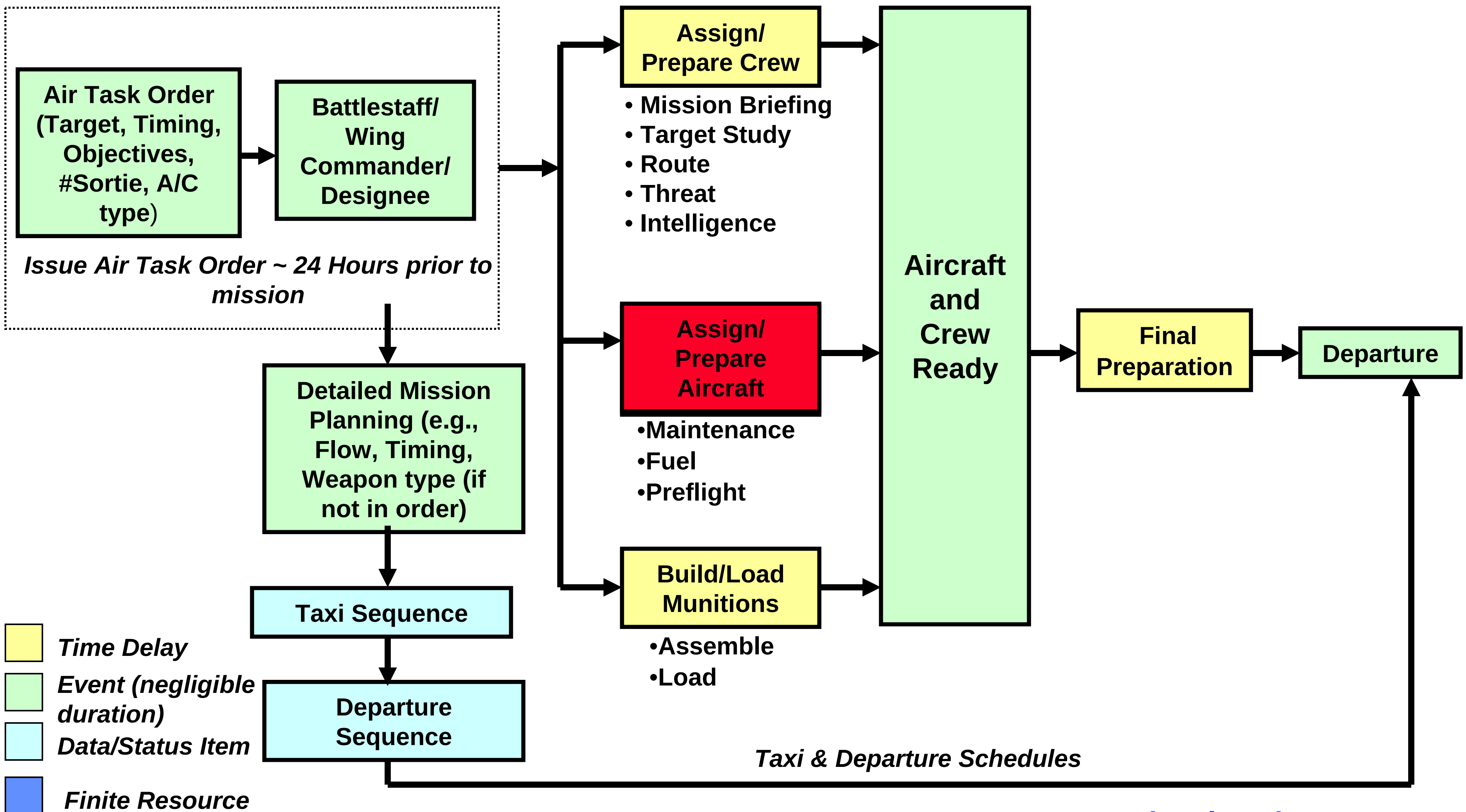
- **Mission definition:**
  - Dispatch 20 fighter aircraft
  - Schedule departures at 1 minute intervals, starting 12 hours after task order
  - Total mission duration 24 hours

- **Selected MOE:**
  - Number of flights departed
  - Mean delay in flight departure
  - Percentage of flights departing on time

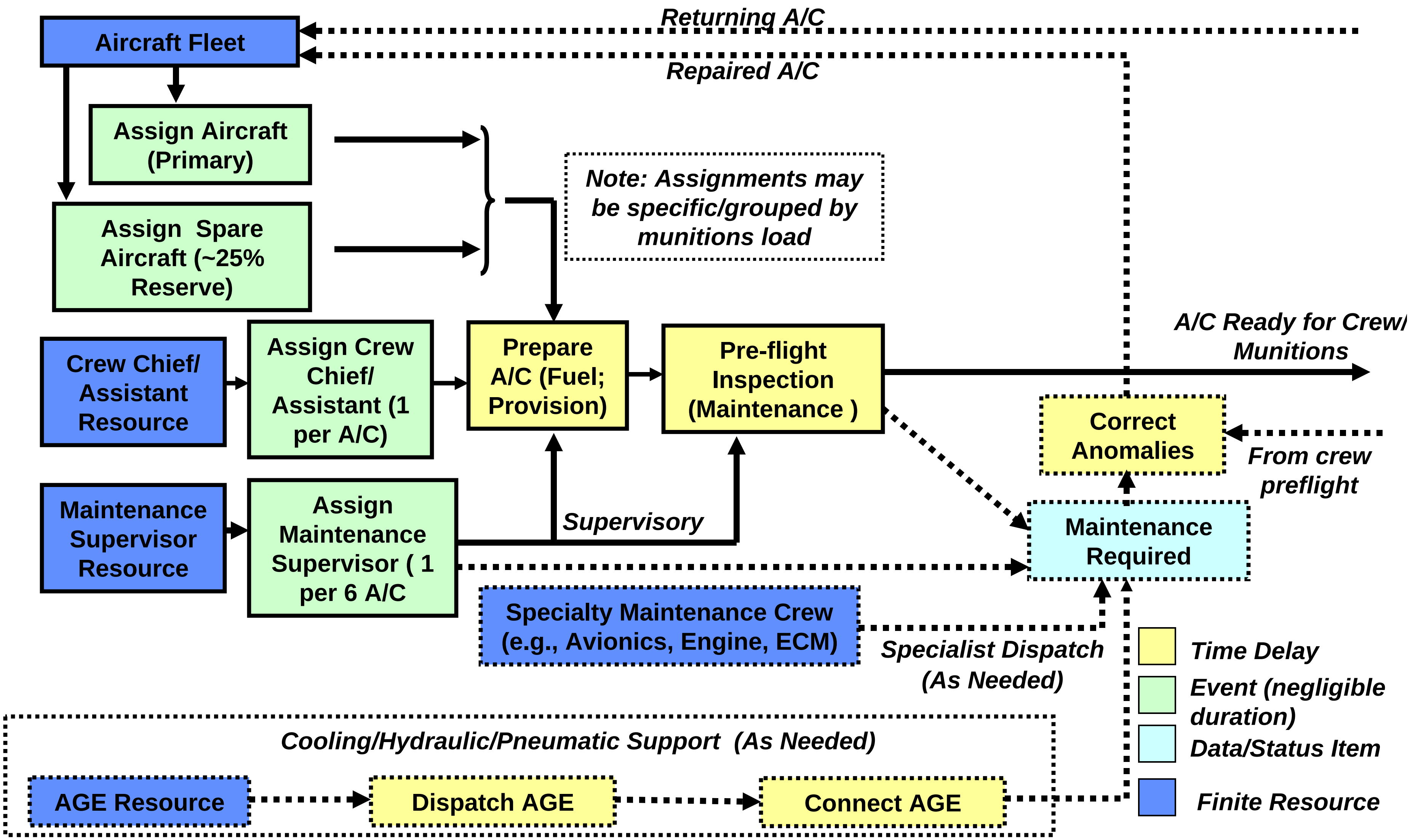
Scenario Concept



Preliminary Mission Structure – Fighter A/C Departure



Preliminary Mission Structure – Aircraft Preparation Detail



Protective Scenarios

- Initial analysis considers alternative MOPP deployment policies
  - Not deployed for ***any*** mission
  - ***All*** critical missions
  - ***All*** critical missions during ***heightened alert***
    - Alert level established by intelligence
  - Operations in ***"high-risk" areas***
    - E.g., near facility perimeter
    - Areas to be identified using threat simulations
  - Operations in ***"high-risk" areas only during heightened alert***

- Implication of MOPP usage
  - Simple tasks require 1.5 times nominal time to complete
  - Complex tasks require 2.5 times nominal time to complete
  - MOPP assumed to provide complete protection

Current presentation

Simulation Parameters for Example Mission

Control Variables	Environmental Variables	Model Variables
• *MOPP Policy* • *Critical Facility Placement* •*Size of Security Perimeter*	• *Attack Type* •*Attack Location* •*Agent* •*Weather*	•*N/A*

Define Feasible Policies

- *MOPP/No MOPP at mission start*
- *Alternative locations for critical activities*

Translate to Policy Simulation Scenarios

- *Code MOPP delay/effectiveness*
- *Code alternative locations in DES*

Statistically Minimize Simulation Scenarios

- *Select scenarios by Factorial Design*

Simulation Parameters for Example Mission

Control Variables	Environmental Variables	Model Variables
• *MOPP Policy* –*None* –*Routine* • *Critical Facility Placement* •*Size of Security Perimeter*	• ***Attack Type*** •***Attack Location*** •***Agent*** •***Weather***	•*N/A*

Define Expected Distributions

- ***Define/ code attack types (e.g., Sprayer, Rocket Launcher)***
- ***Specify attack likelihood***
- ***Specify weather distribution***

Reduce Simulation Set

- ***"Intelligent" scenario selection***
- ***Random sampling***
- ***"Space-filling" designs***

Random Attack Model

Random sampling of attack space is inefficient

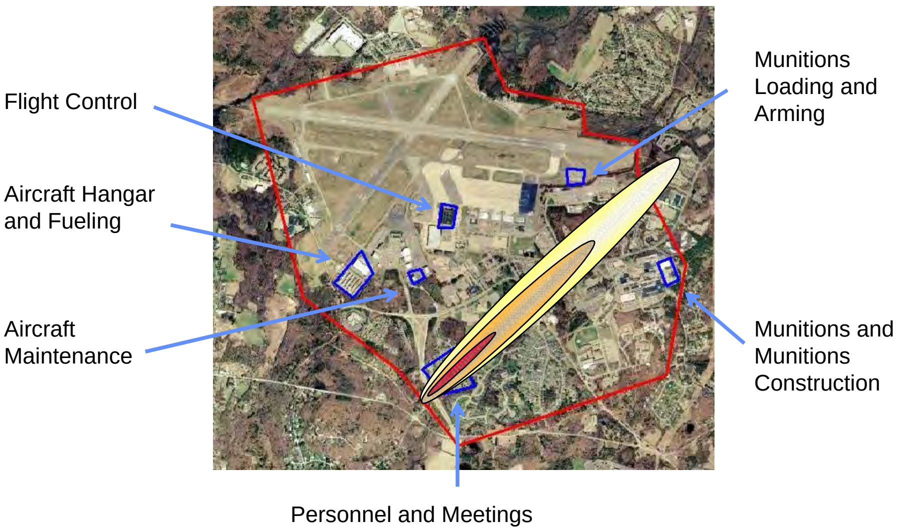
- Case 1: "Random" (40) attacks, distributed evenly around the security perimeter
  - Majority of attacks (97.5 %) affected areas in which no people or critical actions were taking place
  - Minimal effect on mission predicted
  - Assumes little to no planning/intelligence by attacker

Intelligent sampling of attack space is more appropriate

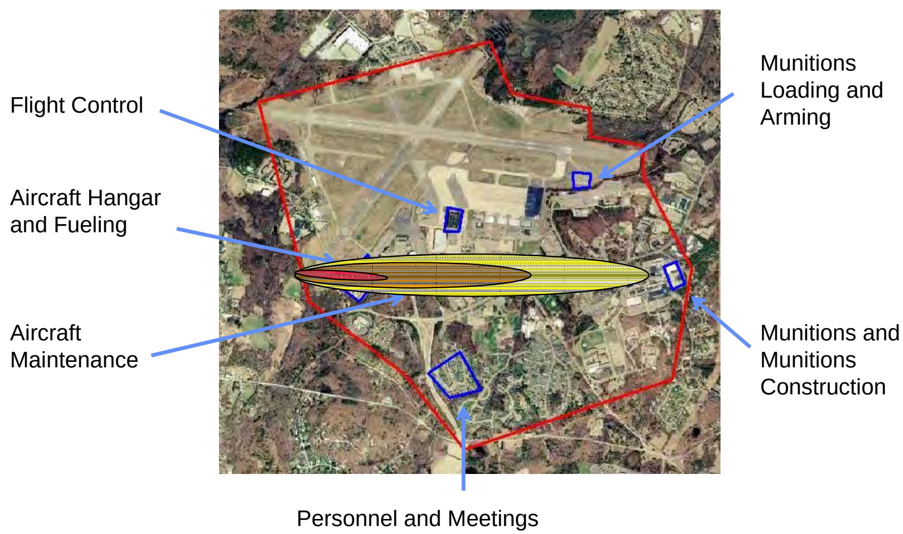
- Case 2: "Intelligent" attack set, directed at operational and/or populated areas
  - All of the attacks affected at least one area important to the mission
  - Mission effect much more significant
  - Likely more realistic representation of potential attack threat

Future efforts will examine applicability of statistical techniques to enhance simulation efficiency (i.e., reduce number of scenarios)

Illustrative Attack Plumes (Backpack Sprayer)



Consequence is highly dependent on attack location and wind direction.



Average Predicted MOE (Illustrative Example)

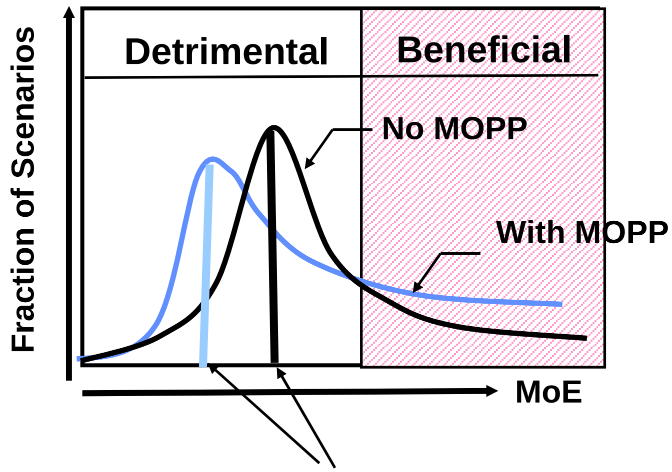
Scenario	Mean Departure Delay (Minutes)	Departures on Schedule (Percent)	Average Flights Departed	Max Sortie Generation Rate** (Sorties/ Minute)
No Attack*	0.1	92.7%	20	0.2
Sprayer* Attack	16.1	87.8%	19.1	0.2
Rocket* Attack	32.3	83.8%	18.2	0.2
Always in MOPP	73.8	0.06%	20	0.08

* Without MOPP

**Predicted maximum possible rate based on ability to prepare aircraft for mission

Based on simple averages, using MOPP at mission start causes more delay than worst case attack……..BUT…

Example Decision Issues (Illustrative Example)

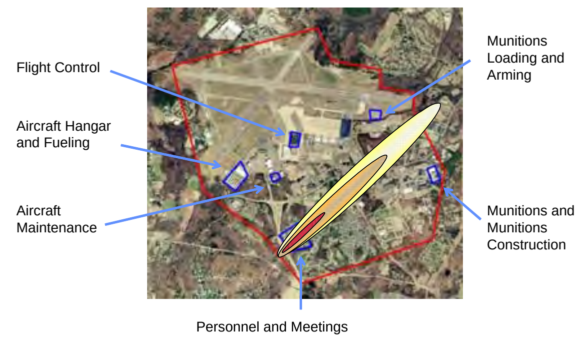


Averages

For the example case, approximately 10% of attacks affected critical facilities sufficiently to benefit from MOPP application

- On average, MOPP is detrimental in terms of delay
- Application of MOPP increases variability in MoE

Well targeted attacks can cause much worse delays than MOPP



- Effective decision strategies must consider not only average performance, but consequences of specific scenarios
  - Likelihood of attack on most critical (“worst case”) operations
  - Information fusion techniques may be applicable

Summary

- **Core program objective is to provide tools to enhance simulation application and result analysis**
  - Agnostic to particular mission simulation tools
  - Eventual integration into JOEF suite
- **Initial activities have provided a "testbed" simulation tool and concepts for mathematical toolset**
  - Discrete event simulation for illustrative mission linked to hazard assessment tool
  - Provides an example against which to test candidate scenario design and analysis concepts
- **Interviews are in progress to characterize key decision processes and possible roles of simulation**
  - Advance understanding of potential JOEF applications
  - Guide development of supporting mathematical tools
  - Delineate key issues in interpreting simulation outputs

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Modeling & Simulation Roadmap for JSTO-CBD IS CAPO

Dr. Don A. Lloyd
Dr. Jeffrey H. Grotte
Mr. Douglas P. Schultz

CBIS // Decision Support
January 10, 2007

Outline

- IT as a CBDP commodity
- The Roadmap problem
- The Roadmap solution
- Advantages & disadvantages
- FY08 program build
- Impacts
- Beyond the Roadmap

IT as a CBDP commodity

- What are we talking about?
  - Computer processors, servers and platforms
  - Communications protocols and infrastructure
  - Development tools & environments
  - Interfaces (e.g. JCID component of JWARN)
  - Methodologies
  - *Of these, only interfaces and methodologies are likely candidates for CBDP basic and applied S&T.*

- We will focus on methodologies
  - They account for more than 90% of the M&S/B S&T program
  - They are the basis for Modeling & Simulation development
  - They are algorithms and heuristics, alone or in combinations
  - They pose unique research challenges for user requirements

M&S differs from other CBDP commodities

- Not just for tools deployed to the warfighter, but also required to support internal CBDP functions
  - Analysis
  - Training
  - Plans and concept development
  - Programmatics
  - Test & Evaluation

- CBDP M&S draws from a broad pool of basic research
  - Numerical mathematics and information theory, but also physics, chemistry, materials science, atmospheric science
  - Methods are not specific to CBRN
  - Fundamental research product is documentation of:
    - Experiments, observations, theorems, phenomenologies
    - Data and their concise generalizations, i.e. small “m” models
    - Results are not specific to Modeling & Simulation
  - Their research products are usually not software

M&S differs from other CBDP commodities

- End-user context is more complicated
  - M&S does not exist in a vacuum
  - In CBDP, M&S is part of a decision support system, for some user-base, to address some set of problems
  - Real world CBRN data used to drive M&S is "dirty"
  - Utility of M&S is based on decision outcomes and risks, not technical performance measures
- Additional requirements of software VV&A
  - (I)V&V focuses on technical merits of software solution
  - Accreditation must also consider use-case and risk
  - Chain of evidence begins with the basic research documentation
  - Closest analog for accreditation is military utility of M&S tool
- These differences suggest that…
  - M&S should be managed differently from CBDP materiel
  - The research opportunities and objectives may not be obvious

The Roadmap in a nutshell

- What are the CAPO responsibilities to CBDP?
  - Satisfy known capability gaps in IS basic research
  - Stimulate new capabilities developed from IS basic research
- CAPO perceptions
  - BAA is inefficient, too many responses, most wide of the mark
  - Difficult to forecast value of any particular project
  - Unsure whether right things are delivered to Program
- Symptoms we observed
  - No objective criteria for evaluating research candidates
  - Mixing of 6.1, 6.2 and 6.3 activities under “6.2”
  - Lack of transparency to proposal writers and reviewers
- Roadmap strategy based upon
  - Review of CBDP, DMSO and other DoD guidance
  - Informal interviews (JPM-IS, JPEO, JRO, JCD-X, T&E & others)
  - Participation in BAA review process for FY06 & FY07

Roadmap objectives

- Make CBRN information systems research and methodologies available for transition when mature.
  - Improve alignment of JSTO M&S investments with CBDP needs
    - Formalize process for obtaining best advice at right times
    - Describe and measure the value of CBRN information
    - Develop objective criteria for evaluating candidate solutions
    - Customize approaches to tech push and requirements pull
    - Accommodate M&S requirements for internal Program functions
  - Assert new measures for the health of the research plan
    - What is the “gold standard” for basic research?
    - Revisit periodically to measure progress and realign efforts
- Acknowledge other stakeholder responsibilities
  - Work within the Implementation Plan for CBDP
  - Focus on research, not software development
  - Be consistent with or improve upon existing JSTO business model

RDT&E 6.1 & 6.2 activities

- Result of 6.1 and 6.2 research is not usually a software product.
- Real currency of research is the scientific documentation, report or article
- JSTO M&S 6.3 funding limited to accumulating data to support transition

- Budget Activity 1, Basic Research. "… systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind."
  - Examples: Heuristics, information theory, threat agent science
  - Products: Peer reviewed paper or equivalent

- Budget Activity 2, Applied Research. "… systematic study to understand the means to meet a recognized and specific need … translate promising basic research into solutions … short of system development … with a view toward developing and evaluating the feasibility and practicality of proposed solutions …"
  - Examples: Error analysis, scalability and feasibility analyses of 6.1 research
  - Products: Technical report or equivalent
  - Some FY05/06 JSTO M&S efforts were categorized 6.2 but included 6.3 software development activities, which are a PM responsibility.

Roadmap obstacles

- Problem definition
  - Too little analysis to know what the technical objectives should be
  - Decision problems are harder than they look
  - No connection between tech performance and operational effectiveness
  - Confusion between basic and developmental S&T

- M&S program management
  - Too little analysis conducted to know whether M&S is required
  - Need for M&S assumed, but often unsubstantiated
  - Acquisition paradigm leaves Program requirements unsatisfied
  - Competing authorities initiate M&S efforts
  - Who pays, why and how?
  - Confusion between data requirements and M&S

- These problems usually occur together, but the Roadmap can only address the first.

The Roadmap solution

- Formalize the process for obtaining best advice *prior* to writing BAA
  - Adopt IPT approach with mix of CBDP and outside participation
  - Specialize strategies for Requirements pull and Technology push
  - Specific objective measures up-front
    - For comparison of competing solutions
    - For greater transparency to proposal writers, and reviewers
  - Leverage existing solutions
    - Not all required methodologies are unique to CBRN applications

- Emphasize peer-reviewed, journal quality report as the basic research product
  - This is the gold standard of research quality
  - Make this an obligation of new and continuing research projects
  - Adds to collective CBDP and DoD knowledge base
  - Provides some assurance that whether a success or failure, the lessons learned are not lost

(Pre-BAA) IPT functions

- Requirements pull IPT functions
  - Recognize whether requirements are adequately defined for tech base
  - Specify the decision context that defines and supports the required capability
  - Define metrics for value of M&S information in decision context
  - Translate operational and analytic requirements into a quantitative specification
  - Determine whether data supporting research are available or must be acquired
  - Determine whether quantified requirements possible without further study
  - Distinguish basic and applied research from customer-developer responsibilities
  - Review published research for acceptable candidates
  - Evaluate research products for satisfaction of requirements and metrics

- Technology push IPT functions
  - Review research proposals from a broad range of disciplines
  - Ask for subject matter reviews on concepts you are unfamiliar with
  - Articulate a concept for using CBRN information
  - Ask for and recognize applicability to CBRN info problems
  - Identify practical research objectives
  - Identify potential customers or recipients for new IS functionality in CBDP

Roadmap advantages

- More efficient use of 6.1 and 6.2 research dollars
- Manages risk in the basic research plan
- JSTO cultivates the state-of-the-art in practices and knowledge.
- BAA review process tailored to benefit decision makers
  - Customers derive benefits of scientific and operational expertise
  - Customers obtain best possible solution for specific needs
  - Expect possibly fewer replies to BAA, but of generally higher quality
  - Tech base able to effectively respond to quantitative requirements
  - Improve concepts for information tools and establish their utility
  - Clearer research performance criteria
- Roadmap is flexible
  - Make CBDP IS research process available for analytic, training and other unwritten requirements
  - Open process further to new ideas or concepts that enhance or extend CBDP IS capabilities
  - Push and pull procedures can run concurrent or not
  - Roadmap performance can be measured with a “gold standard”

Roadmap disadvantages

- Managing the IPTs will require
  - More time
  - More people
  - Wider variety of expertise
  - Commitments to meet regularly
  - Coordination of S&T plan with DHS, DARPA
  - More expensive than current approach

FY08: A rebuilding year

- FY08 begins the transition to technology push
- Articulate a CBDP concept for using CBRN information
- Key questions to ask of any basic research opportunity
  - What is the motivation for the subject as a research topic?
  - What are the prevailing theories or phenomenological approaches?
  - What experiments have been conducted, and how do they reconcile with theoretical work?
  - What kinds of problems do experts think the subject matter could be applied to?
  - What feasibility studies have been conducted?
  - What successful applications of the research? What attempts have failed and why?
- Use what is learned in FY08 to select best CBDP opportunities in FY09 and out
- Asking for written subject reviews, not software solutions

Roadmap impact on multiple communities

- Contractors/developers
  - Easier to write proposals that go to your strengths
  - Implementation contracts revert to Program or Tech. Demonstration Manager
- Universities
  - Most viable basic research candidates should come from universities
  - But, many programs not used to proposing for DTRA funding
- Service Labs/FFRDC Labs
  - Source of military smarts for technology
  - Likely recipient of an intermediate technology transition
  - Manage application and early development as technology demonstration – very important role
- CBD Program officials
  - Best approach to managing risk in basic research plan you will ever get, easier to measure health of a diverse research plan
  - Avoids over-commitment to novelty, balances well with incremental research plans

M&S management observation

- M&S is a poor candidate for acquisition
  - Requirements documents capture the wrong thing – they describe the tool but not the process and consequence of using the tool
  - Acquisition Program Manager inherits all of the overhead and management apparatus used to make boots and gloves, but has no flexibility to respond to internal Program requirements.
  - Need a Configuration Control Board represented by all CBDP components and users to direct the PM.
  - Example: JICM is a Program of Record, with evolving requirements, managed by a CCB.

CBRN Data Backbone

Eric Lowenstein
Joint Science & Technology Office for
Chemical & Biological Defense (JSTO-CBD)
March 30, 2007

Outline

- The Data Problem
- CBRN Data Backbone
- First steps:
  - Steering Committee
  - Feasibility Study
    - Study Plan

The Data Problem

- Most CBRN data, critical to current and future programs is:
  - Not validated
  - Inaccessible
  - Unreliable
  - Unstructured and structured data distributed everywhere
  - Legacy database architectures are unsuitable for current applications
- While the CBRN Data Model formalizes data transfer between M&S applications, no provision has been made for the storage, maintenance, and reuse of CBRN data
- Many organizations lack tools to assist in critical analysis functions; i.e.:
  - Policy and planning
  - Fiscal decision making
  - Engineering trade studies
  - Systems development
  - CONOPS development
  - Test analysis

CBRN Data Backbone

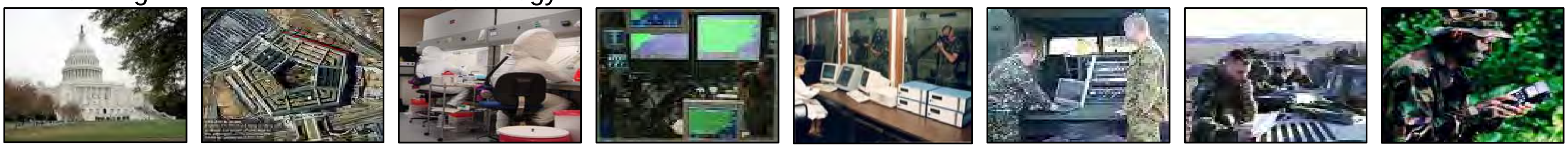
- It is critical that a new program be established to carry out the functions necessary to construct, employ, maintain, and safeguard a system for the access of validated CBRN data.

- This system will:
  - Contain validated CBRN data, piecewise-accessible to different communities as appropriate for security and efficiency
  - Provide rapid access over the Internet or applicable secure networks (NIPRNET, SIPRNET, etc.)
  - Be interactive, to the extent possible, to provide the most utility to users
  - Assist in identifying gaps in data and evaluating the fidelity of existing data
  - Prevent repetition of costly and time-consuming testing
  - Allow easy entry of new validated data

CBRN Data Backbone

Multiple User Communities

Policy & Planning | Acquisition | Science & Technology | Analysis | Test & Evaluation | Experimentation | Training | Operations



Strategic Analysis
- Decision Support Tools

S&T Gap Analysis & Identification of Areas for Future Research

R&D Modeling & Analysis
- Product Development Models

Materiel and Personnel Performance Evaluation

M&S in Support of T&E
- Design of Tests
- Validated Capture of Test Data
- Overarching T&E Models

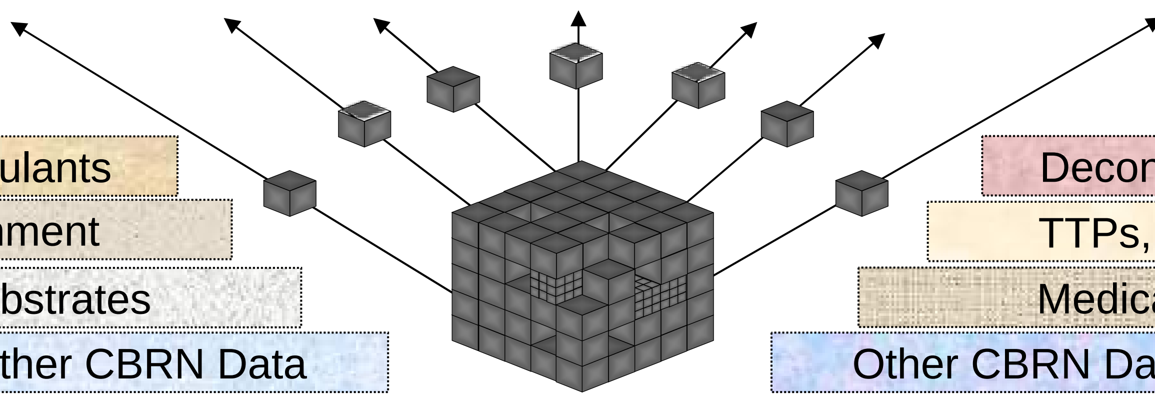
Design of Experiments

Operational IS
- JWARN
- JEM

Operational M&S & Analysis
- JOEF

Design of Training Exercises

Multiple Applications



Agents & Simulants

Environment

Substrates

Other CBRN Data

Decon/ColPro/IP/CA

TTPs, ConOps

Medical

Other CBRN Data

CBRN Data Backbone

Challenges

- Security
- Validation
- Stable, efficient architecture
- Volume
- Retrieval speed
- Maintenance

- Other challenges expected to be uncovered during the course of the JSTO-funded study

First Steps

- Create Steering Committee to guide all efforts related to Data Backbone development.
  - JSTO will coordinate the Steering Committee congruously with the study

- Conduct a study of the concept's feasibility and potential architectures
  - JSTO kicked off an 18-month study on October 11, 2006

- Objective: Provide the DoD with knowledge superiority and efficiency and increase the defensive capabilities and effectiveness of the warfighter through the accuracy, interoperability, and reuse of validated CBRN data

Steering Committee

Steering Committee Objective:

- Consider CBDP strategies to provide guidance and recommend investment for Data Backbone development

The CBRN Data Backbone Steering Committee will:

- Guide data backbone program development by providing policy direction and strategic planning, and providing oversight of critical development efforts.
- Prioritize and recommend investments.
- Meet quarterly to review development and provide timely guidance on critical issues. Meets at higher frequency respective of investment cycle.
- Include representatives from the JRO, JPEO, JSTO, and the T&E Executive, but also PDTESS, DOT&E, DMSO, other agencies/orgs as appropriate.

Feasibility Study

- Objective: Investigate the feasibility of and potential architectures for constructing a CBRN database that is validated, web-based, and interactive. Among other activities, this will include an investigation into:
  - What data exists? Where is it? Who uses it? Is it reliable? …
  - Feasible architectures (ensure coordination with Service-Oriented Architecture being developed by JPM-IS)
  - Challenges and potential risks
  - Appropriate measures of comprehensiveness for CBRN data
  - How to establish a process for submission of data
  - Any other issues of concern for backbone construction, including those voiced by the Steering Committee
  - Combined recommendation at the end of the study (March 2008) for the 2010-2015 POM submission by JPEO and JSTO

Study Constraints

1. Study duration is 18 months
2. It is an applied research study, not an IT project
3. Government support is REQUIRED to identify and access data providers, sources, and users
4. Study is driven by the data & user requirements, not existing data constructs or IT/IS tools or technologies
5. Technical requirements will address current and future needs
6. Study focus is the M&S CBRN COI
7. This study will focus on both physical S&T and medical data for M&S and IS

Study Plan

1. Identify data users and their data requirements
2. Identify data users' data fidelity requirements
3. Identify gaps between data requirements and existing data
4. Assess data mining, warehousing processes, technologies, and tools
5. Provide recommendations for a plan for developing the CBRN Data Backbone (a data collection, enterprise architecture, storage and access system)

1.a. Identify data users

Scope

- The Study Team will determine the sets of CBRN data users and formulate a representative set of data users within the operational, training, analysis, and test & evaluation communities.

Key task #1

- Develop user survey

Products

- List of CBRN data users
- Documentation with analysis of survey results

1.a. Identify data users

Scope

- The Study Team will determine the sets of CBRN data users and formulate a representative set of data users within the operational, training, analysis, and test & evaluation communities.

Key task #2

- Interview users to determine a set of fundamental scientific relationships that are of importance to each user, as well as the associated set of data types.

Products

- List of CBRN data users data types and tools
- Documentation with analysis of interview

1.a. Identify data users

Scope

- The Study Team will determine the sets of CBRN data users and formulate a representative set of data users within the operational, training, analysis, and test & evaluation communities.

Key task #3

- Show relationships between them, as a function of CBRN data Identify specific data, data types and tools produced or used by each type of CBRN data user.

Product

- Illustration of CBRN data relationships that exist between data users

1.b. Identify data users' needs

Scope

- The Study Team will determine the sets of CBRN data users and formulate a representative set of data users within the operational, training, analysis, and test & evaluation communities.

Key task #1

- Input will be sought from users. The interrelationship between different users data requirements will be used to define user needs.

Products

- List of data user data needs
- Illustration of the relationships between users and data

1.b. Identify data users' needs

Scope

- The Study Team will determine the sets of CBRN data users and formulate a representative set of data users within the operational, training, analysis, and test & evaluation communities.

Key task #2

- Develop a "data life cycle" of the CBRN community

Product

- Comprehensive description of data life cycle

1.b. Identify data users' needs

Scope

- The Study Team will determine the sets of CBRN data users and formulate a representative set of data users within the operational, training, analysis, and test & evaluation communities.

Key task #3

- Evaluate data types identified by users against JPM-IS Data Model

Products

- Summary of evaluation of CBRN data types against DOM

2. Identify data fidelity requirements

Scope

- The Study Team will formulate a notional set of data fidelity requirements that apply to each user.

Key task #1

- Define a fidelity scale that can be used to quantify data usability from user input

Product

- Description of data fidelity scale

2. Identify data fidelity requirements

Scope

- The Study Team will formulate a notional set of data fidelity requirements that apply to each user.

Key task #2

- Apply a notional fidelity scale to data requirements

Product

- Summary of results of applying the notional fidelity scale to data requirements obtained in part 1

2. Identify data fidelity requirements

Scope

- The Study Team will formulate a notional set of data fidelity requirements that apply to each user.

Key task #3

- Use data fidelity scale to determine how data can be categorized in the CBRN Data Backbone

Product

- Description of the data categories generated by application of fidelity scale

3. Assess existing technologies

Scope

- Based on analyses of CBRN users and their requirements, the Study Team will recommend technologies and IT-based tools.

Key task #1

- Develop a list of technical requirements based on data utilization and fidelity requirements, as well as a Service Oriented Architecture (SOA) utilizing Network Centric Enterprise Services (NCES) standards.

Product

- A list of potential technologies
- Technology selection criteria document

3. Assess existing technologies

Scope

- Based on analyses of CBRN data users and their requirements, the Study Team will recommend technologies and IT-based tools.

Key task #2

- Identify potential processes and or technical solutions to enhance a user's relationship to data.

Product

- A description of the notional set of processes to utilize the technology

3. Assess existing technologies

Scope

- Based on analyses of CBRN data users and their requirements, the Study Team will recommend technologies and IT-based tools.

Key task #3

- Document data flows in accordance with client requirements and industry best practices.

Product

- Data Flow Document

3. Assess existing technologies

Scope

- Based on analyses of CBRN data users and their requirements, the Study Team will recommend technologies and IT-based tools.

Key task #4

- Develop a technology integration concept

Product

- Technology integration document describing technology integration considerations and recommendations

3. Assess existing technologies

Scope

- Based on analyses of CBRN data users and their requirements, the Study Team will recommend technologies and IT-based tools.

Key task #5

- Address the development of a web services based data storage and access system.

Product

- Document that describes issues regarding the development of a web services-based data storage and access system.

3. Assess existing technologies

Scope

- Based on analyses of CBRN data users and their requirements, the Study Team will recommend technologies and IT-based tools.

Key task #6

- Create a development plan for prototype data storage and access system.

Product

- Development plan document.

4. Assess data availability

Scope

- The Study Team will assess the availability of the required CBRN data, and the feasibility of obtaining the data that is not readily available.

Key task #1

- Utilize data requirements list generated in 1b. to determine specific areas of data availability for investigation

Product

- Document describing data availability

4. Assess data availability

Scope

- The contractor will assess the availability of the required CBRN data, and the feasibility of obtaining the data that is not readily available.

Key task #2

- Review existing JSTO S&T programs to determine if the data requirements listed during 1b. are being met, or if similar data is being generated

Product

- Document describing JSTO S&T data requirements connections to or gaps between data that is available or being generated

4. Assess data availability

Scope

- The Study Team will assess the availability of the required CBRN data, and the feasibility of obtaining the data that is not readily available.

Key task #3

- Review non-JSTO programs to determine if the data requirements listed during 1b. are being met, or if similar data is being generate

Product

- Document describing non-JSTO S&T data requirements connections to or gaps between data that is available or being generated

4. Assess data availability

Scope

- The Study Team will assess the availability of the required CBRN data, and the feasibility of obtaining the data that is not readily available.

Key task #4

- Assess the types of data that are required, the scientific efforts that must be undertaken to obtain the data, and an approximation on the time and financial resources needed to obtain the data.

Product

- Document describing identified data gaps, with approximate measures of resources available to obtain data needed to fill gaps

5. Final report

Scope

- The Study Team will provide recommendations for a prototype data storage and access system development plan, including a description of the data and associated fidelities.

Key tasks

- Combine and interpret the results of the study phases
- Describe the user-to-data relationships
- Compile the list of data sources and repositories; describe existing data
- Describe the IT-based tools and technologies best suited to store and retrieve CBRN data, using a well defined evaluation criteria

Products

- CBRN Data Backbone Study (text document)
- Executive Briefing

Questions?

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RiskAware. solutions for life

A concentration fluctuation model for virtual testing of detection systems

Presented by:

Dr Martyn Bull and Dr Robert Gordon

Contents

- Rob Gordon - Overview
  - Definition of concentration fluctuations
  - Why model concentration fluctuations?
  - Why do we need a better model?
- Martyn Bull – Technical Approach
  - Chosen Approach
  - Initial results
  - Future Work

Definition of Concentration Fluctuation

"The variation of concentration in space and time from an averaged distribution"

Why Model Concentration Fluctuation (1)

- Growing need to evaluate sensor network functionality and performance
- Development and testing of complex processing algorithms entirely using field data can be expensive and impractical
- Processing algorithms will often be developed in parallel with hardware

Why Model Concentration Fluctuation (2)

- Therefore a need for:
  - Realistic simulated challenge concentration fields
  - Realistic simulated background fields
- Problem Definition
  - **To develop a model which will enable us to simulate the behaviour of detectors within a real plume**

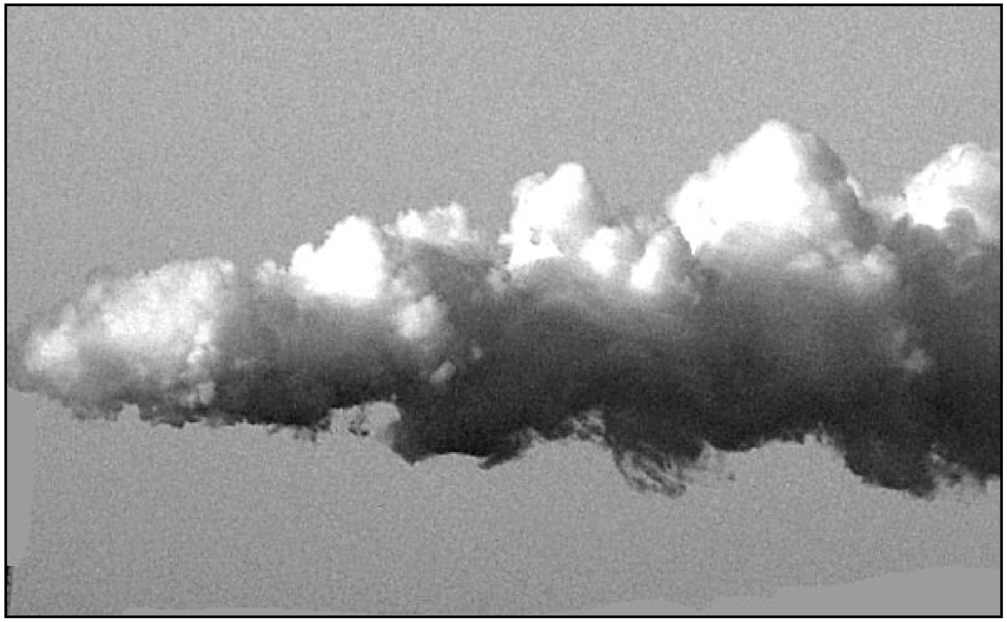
Existing Dispersion Model Approaches

- Gaussian puff models e.g. SCIPUFF, UDM
  - Produce ensemble predictions of concentration, with estimates of variance
- Single Particle models – e.g. NAME, FLEXPART
  - Produce ensemble mean predictions of concentration
- CFD
  - Dynamic CVD provides a detailed model but is computationally expensive
- Other technologies (e.g. LES, two particle models)
  - Could provide a detailed model, but are computationally expensive

Ensemble Models

- An ensemble is an average of all possible model runs
- BUT an ensemble looks very different to a real cloud AND real background data is very different from a flat mean value
- If we train and design our system against ensemble simulations we cannot expect it to behave in the same manner in a to real plume.

Real plume vs. ensemble plume



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Technical Approach

Fluctuation Characteristics (1)

- Concentration fluctuates around an ensemble mean value
- Fluctuations can be approximated by a **clipped** normal distribution
  - In some cases concentration can fall to zero
- Fluctuations show a degree of **temporal** correlation –
  - i.e. the concentration at time T + dT is related to concentration at time T

Fluctuation Characteristics (2)

- Fluctuations show a degree of **spatial** correlation
  – i.e. the concentration at a given location is correlated with the correlation at surrounding locations
- Spatial correlations have limited range
  – depends on fluctuation **length scale**
- Correlation down-wind is different to correlation cross-wind
  – Crosswind correlations have short range
  – Downwind correlations have longer range and a time delay

Possible approaches (1)

- Meander model and gaussian puff model (Gifford, 1959)
  - Produces large scale fluctuations but not small scale
- Markov chain (random walk) local concentration fluctuations
  - Models small scale fluctuations but without spatial
- Spatial correlation forcing. (i.e. adding correlation to independent fluctuation models)
  - Becomes an n-squared problem hence scales VERY badly on large scenarios

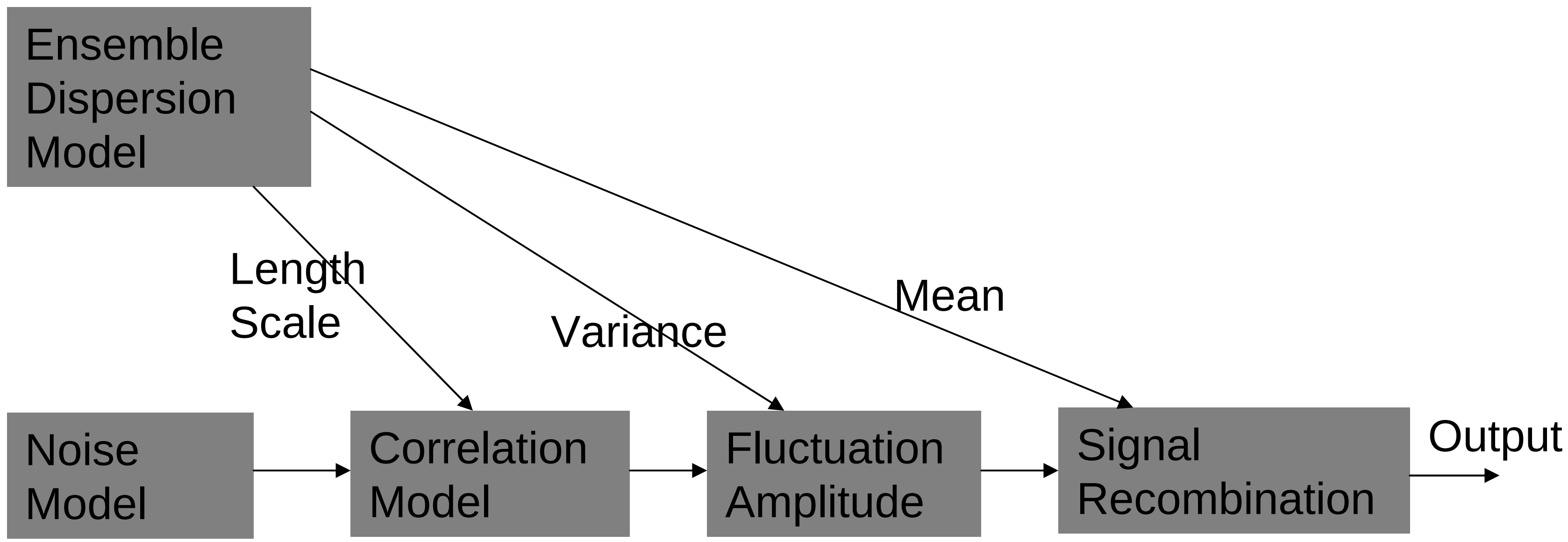
Possible approaches (2)

- Computational Fluid Dynamics
  - Dynamic CVD could provide answers but very high computation cost
- Other technologies (e.g. LES, two particle models)
  - Immature and un-validated for this domain of use
  - Computationally expensive

Chosen approach – the Fluctuation Model

- Use a validated dispersion model to provide ensemble predictions
  - Concentration mean
  - Concentration variance
  - Fluctuation length scale
- Simulate a noise field separately
  - Using variance and fluctuation length scale from dispersion model
- Recombine with ensemble mean afterwards

Concentration Fluctuation Model - Software Architecture



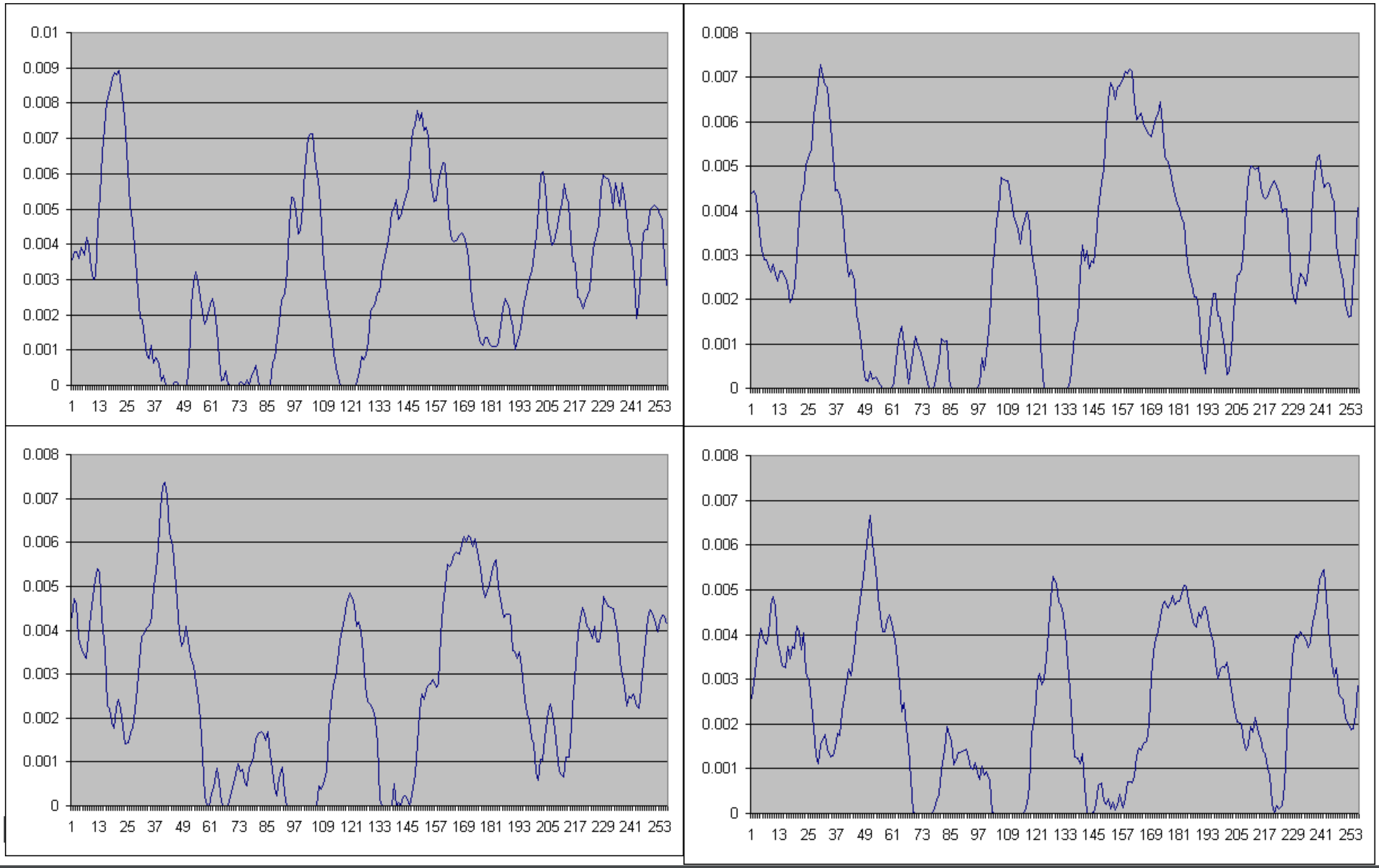
Model description (1) Noise Model

- Uses Hidden Markov Model (HMM) paradigm
- Underlying white noise field distributed over space
- Moves downwind with time
- Modified (mutated) with time
  - Via stochastic cell-swapping
  - Via individual random walk at pixel lebel

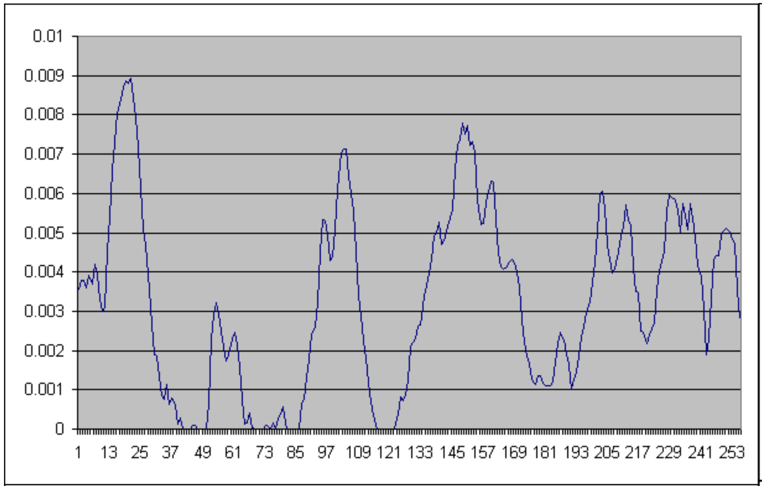
Model Description (2) Correlation Model

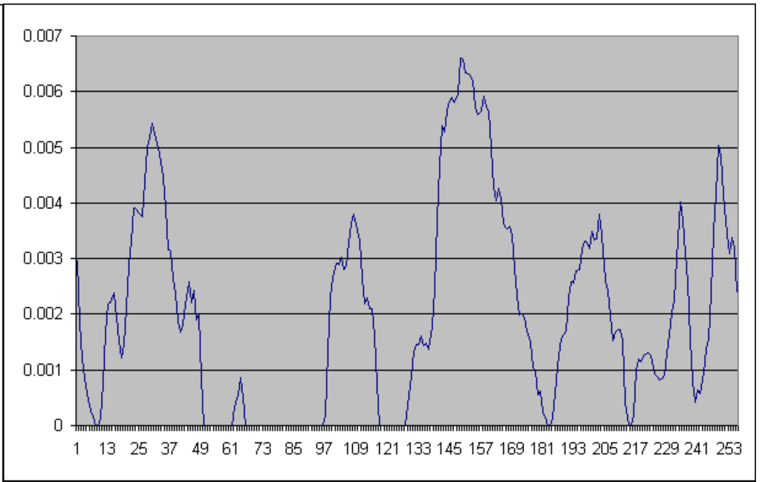
- Spatial filtering used to add in spatial correlation
  - Temporal correlation emerges as a side effect
- Smoothing kernels:
  - computed on startup
  - based on image processing methods
- Input length scale determines selection of kernel at each location

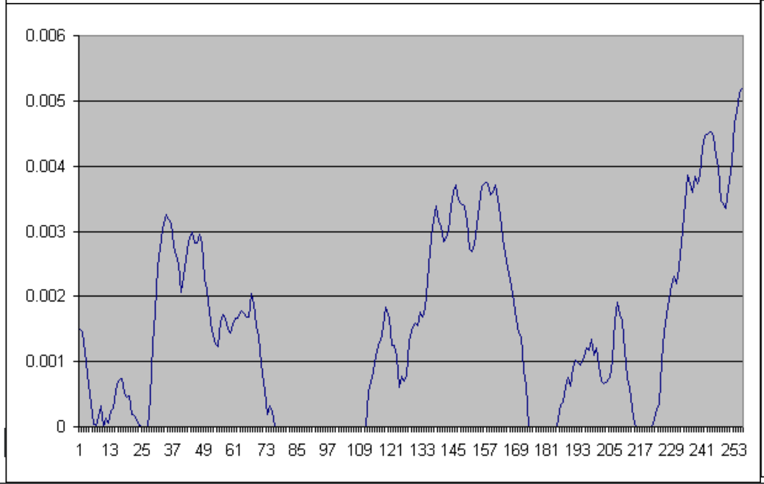
Model Output (1) – Downwind Fluctuation Correlation

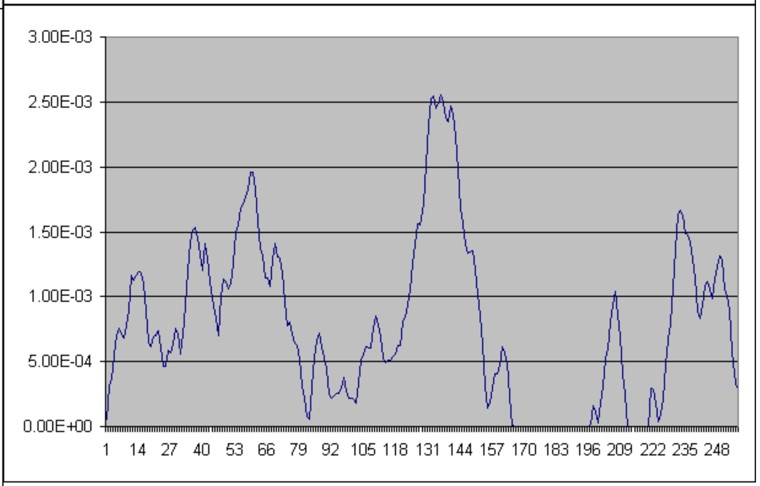


Model Output (2) – Crosswind Fluctuation Correlation



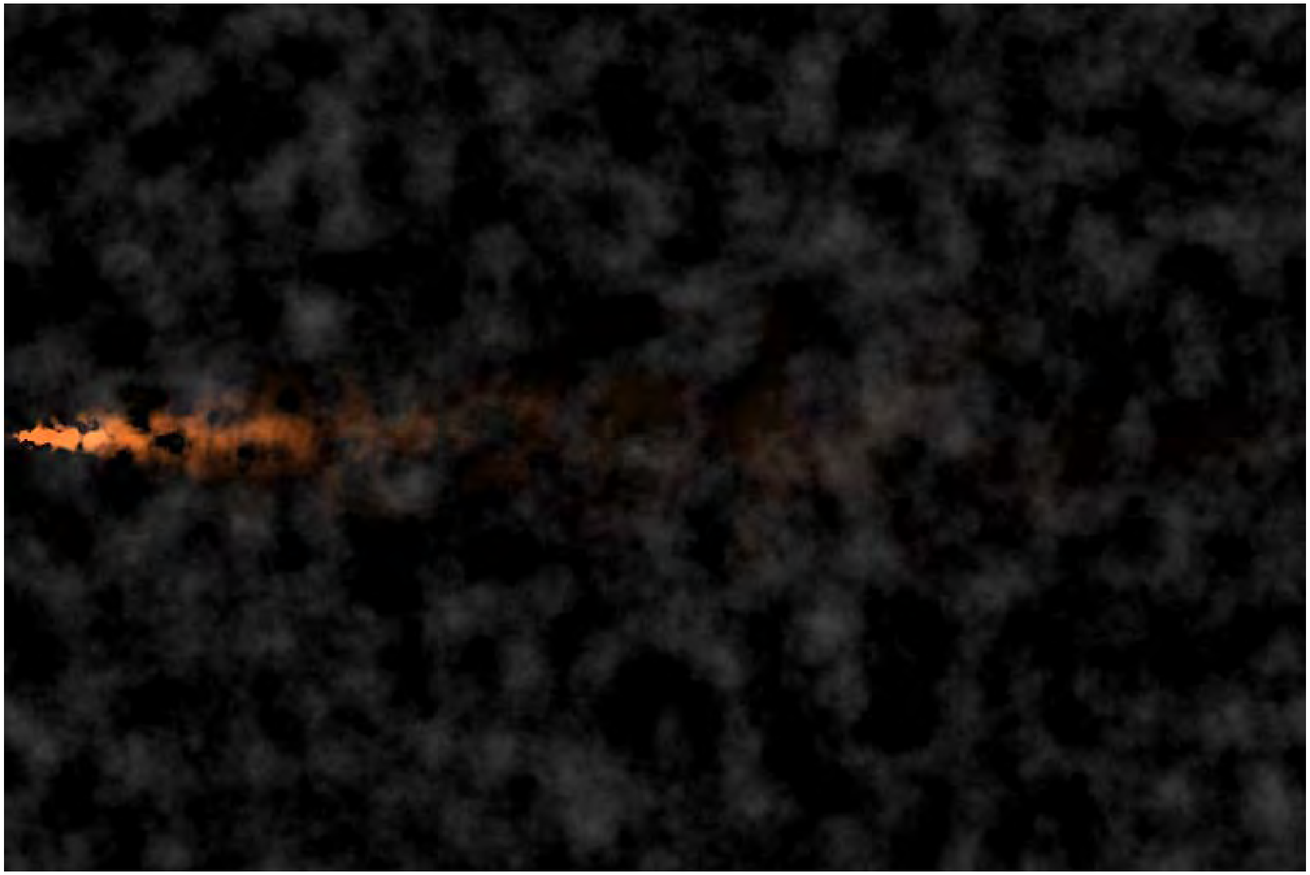






Model Output (3) – Point release with zero background

Model Output (4) – Point release with significant background



Key advantages

- Based on validated model
- Mean, and variance match the model
- Fluctuations match model predictions
  - Also adds significant refinements
    - Crosswind correlations low
    - downwind correlations high
    - time delay in downwind correlation

Current Model Status

- A standalone software module
  - Developed in pure Java
  - Straightforward system integration path
- Could be used in near-term to create virtual testing solutions for specific systems
  - LIDAR
  - Detector Arrays

Future work (1)

- Use in combination with puff model and a meander model
  - Model would be restricted to synthesizing small-scale correlations giving faster computation
  - Would provide greater fidelity close to source
- Multi-species background modeling
  - With controllable correlation between species
- Extend model to give full 3D fields for some future applications
  - Currently provides a two dimensional slice

Future work (2)

- Hardware implementation of model
  - Compilation down to Field Programmable Gate Array (FPGA) hardware program
  - Enhanced real-time performance
- Embedded implementation in detector hardware (e.g. LIDAR)
  - For system firmware/software evaluation
  - For operator training
  - For exercise support

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Questions?

EXPANDING THE REALM OF POSSIBILITY

Medical Modeling of Particle Size Effects for Inhalation Hazards

Chem-Bio Information Systems 2007

Austin, TX

Gene McClellan, Jason Rodriguez and Kyle Millage

10 January 2007

Joint Science and Technology Office — Modeling and Simulation — Battlespace Management — Chemical and Biological Defense

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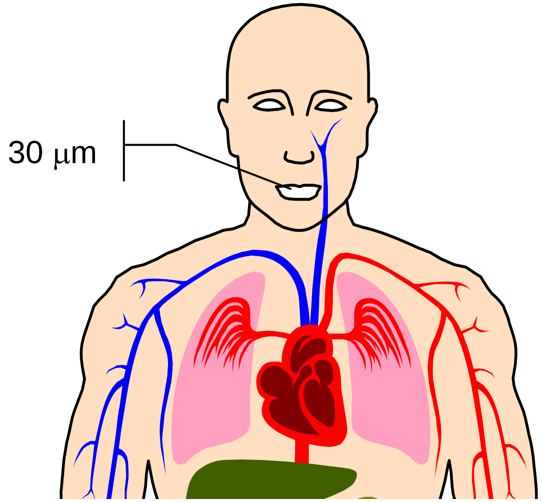
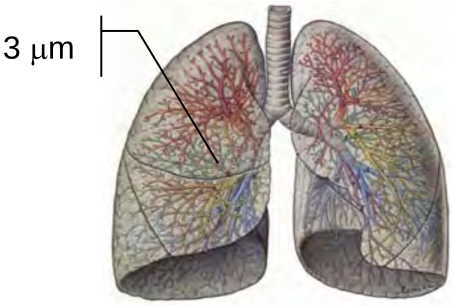
Topic Outline

- Objective
- Background
- Why should we care
- Inhalation mechanics
- Dispersion by particle size
- Anatomy and biokinetics
- Conclusion

Objective

- Develop medical models for the influence of aerosol particle size on the health effects of inhaled CBRN hazards to improve hazard assessment, particularly in urban environments.





Background – Aerosol Inhalation

- Techniques well developed for radionuclides and atmospheric particulates
  - Inhalation mechanics well established
  - Human response well studied
- Particle size modeling is incomplete for chem-bio agents
  - Inhalation mechanics is applicable
  - Critical new piece is variation in human response

Modeling of Particle Size Effects in CBRN Consequence Assessment Is Incomplete

- Used in atmospheric transport
  - Nuclear fallout directly dependent on settling
  - CBWPN in HPAC allows User to specify a lognormal particle size distribution
- Radionuclide dose conversion factors for inhalation account for particle size
- Inhalation model for CB agents is crude
  - Typically assume 5 μ particles, 100% inhaled
  - Or use a size cut-off like 10 μ
  - Neglected for liquid agents

Why Should We Care?

- Often-expressed beliefs
  - Can neglect large particles
    - They settle out too quickly
    - Don't penetrate deeply into the lung
  - Can neglect small particles
    - Not retained in lungs

- These are arguments for efficacy of 3 - 5 μ range
  - Valid, but…
  - Arguments do not support the converse!

Particle Size-Dependent Tularemia

Macaca mulatta (rhesus) monkeys[1]

Particle size	2.1 and 7.5 μm	12.5 and 24.0 μm
Exposed	48	45
% Infected	100%	84%
Onset Time	2-3 Days	6-10 Days
Primary infection site	Lower respiratory system, pneumonitis	Upper respiratory tract, nasal pharyngeal area, cervical and mandibular lymph nodes; eyes (15%)
% fatal	69%	53%
Time to death	4-8 Days	8-21 Days
LD_{50} (organisms)	14 and 378	872 and 4,447
LD_{50} (particles)	14 and 28	11 and 8

[1]Data from Day and Berendt., 1972.

Particle Size-Dependent Ricin Intoxication

BALB/c mice[1]

Particle size	1.0 μm	5.0 and 12.0 μm
Exposed mice	48	48
Dose delivered (fixed)	~4.5 times the LD_{50}	~3.7 times the LD_{50}
Regional deposition (1-hr post-exposure)	60% lungs 20% trachea 10% nares 10% stomach	20% lungs 80% trachea
% affected	Ricin binds to almost all mammalian cells, allowing for effects on most cell types	
% fatal	100%	0%
Time to death	Within 72 hours	--

[1]Roy et al., 2003.

•The large particles lack regional deposition into pulmonary portion of lung
 -Do not affect cell types necessary to induce a lethality

The Respiratory Tract Has Three Anatomical-Functional Regions

- Head (or extra-thoracic, ET) airways
  - Nose and mouth to the larnyx
  - Nasal airways and the oral cavity
- Tracheobronchial (TB) region
  - Larnyx to the terminal bronchioles
  - Ciliated epithelium, mucous-secreting
- Pulmonary (P) region
  - Respiratory bronchioles to the terminal alveoli
  - Gas-exchange epithelium, non-ciliated

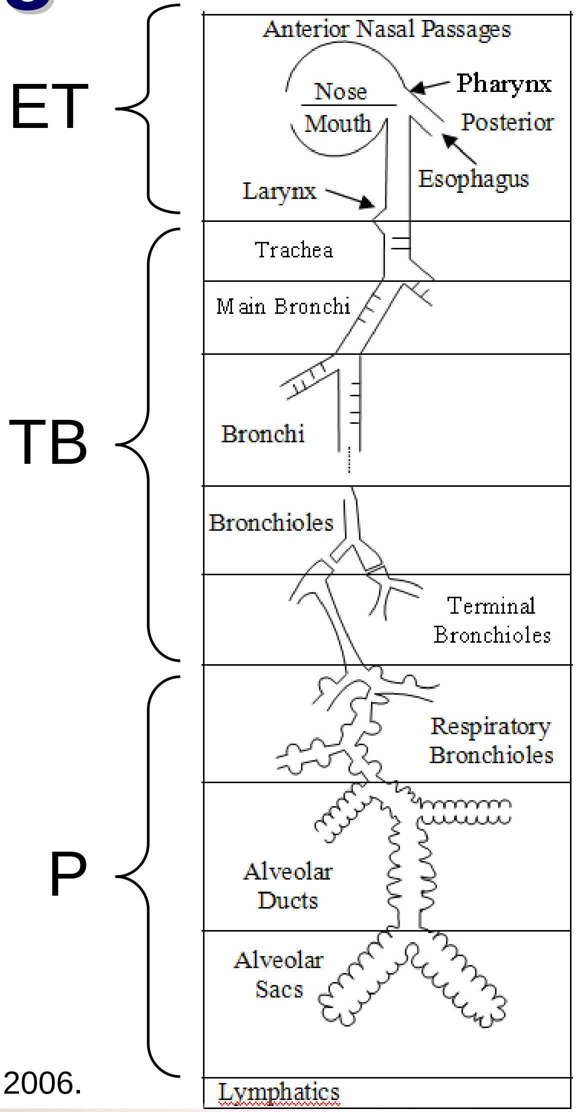


Illustration from Asgharian et al., 2006.

Deposition vs. Size Is Complex

Humans.
Nasal breathing.
Fraction of inhaled particles.

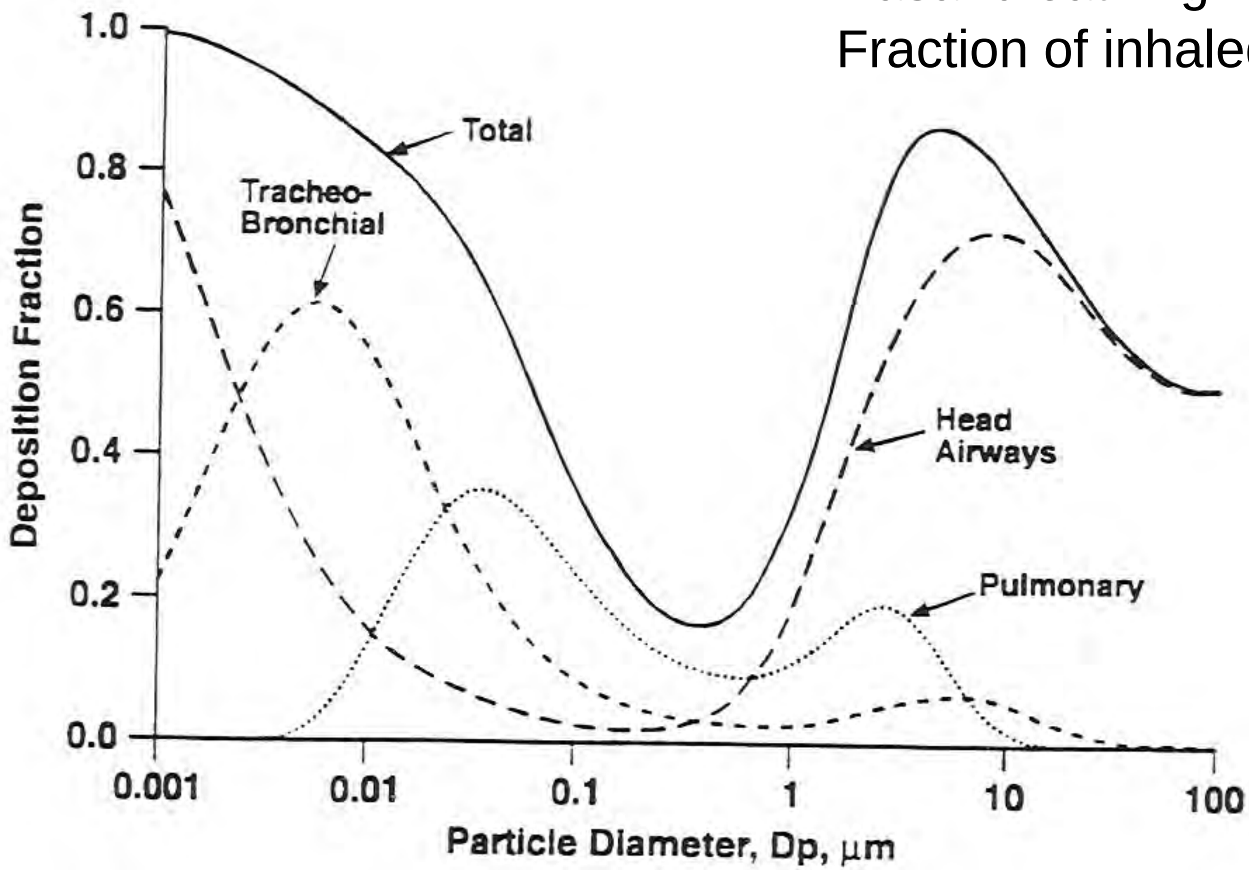
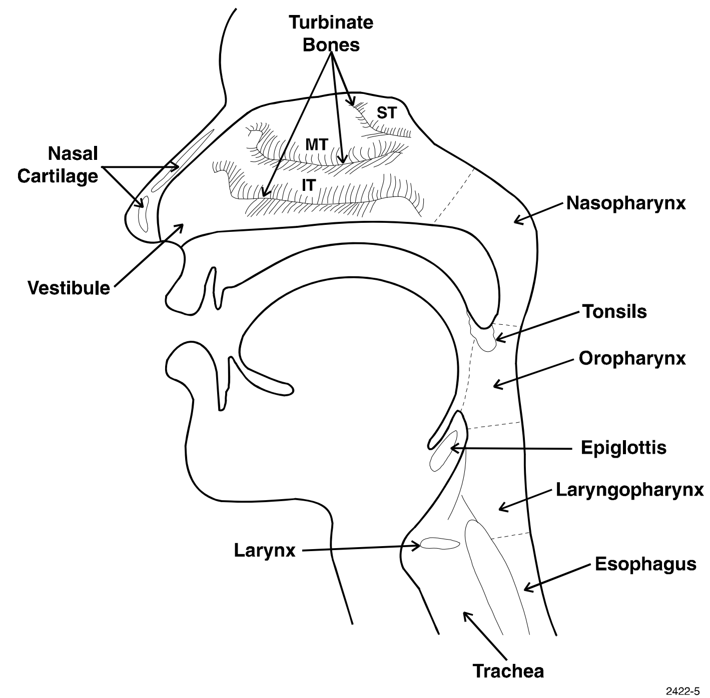


Illustration from Snipes, 1994.

Inhalability Factor Is Important for Particles Larger Than 3 - 5 μm

- Inhalability $I(d_{ae})$ measures likelihood of particle inspiration
- Nasal breathing only,
  - I approaches 0 for particles larger than 100 μm[1]
- Oronasal breathing,
  - I remains 0.5, even for particles 100-150 μm[2]

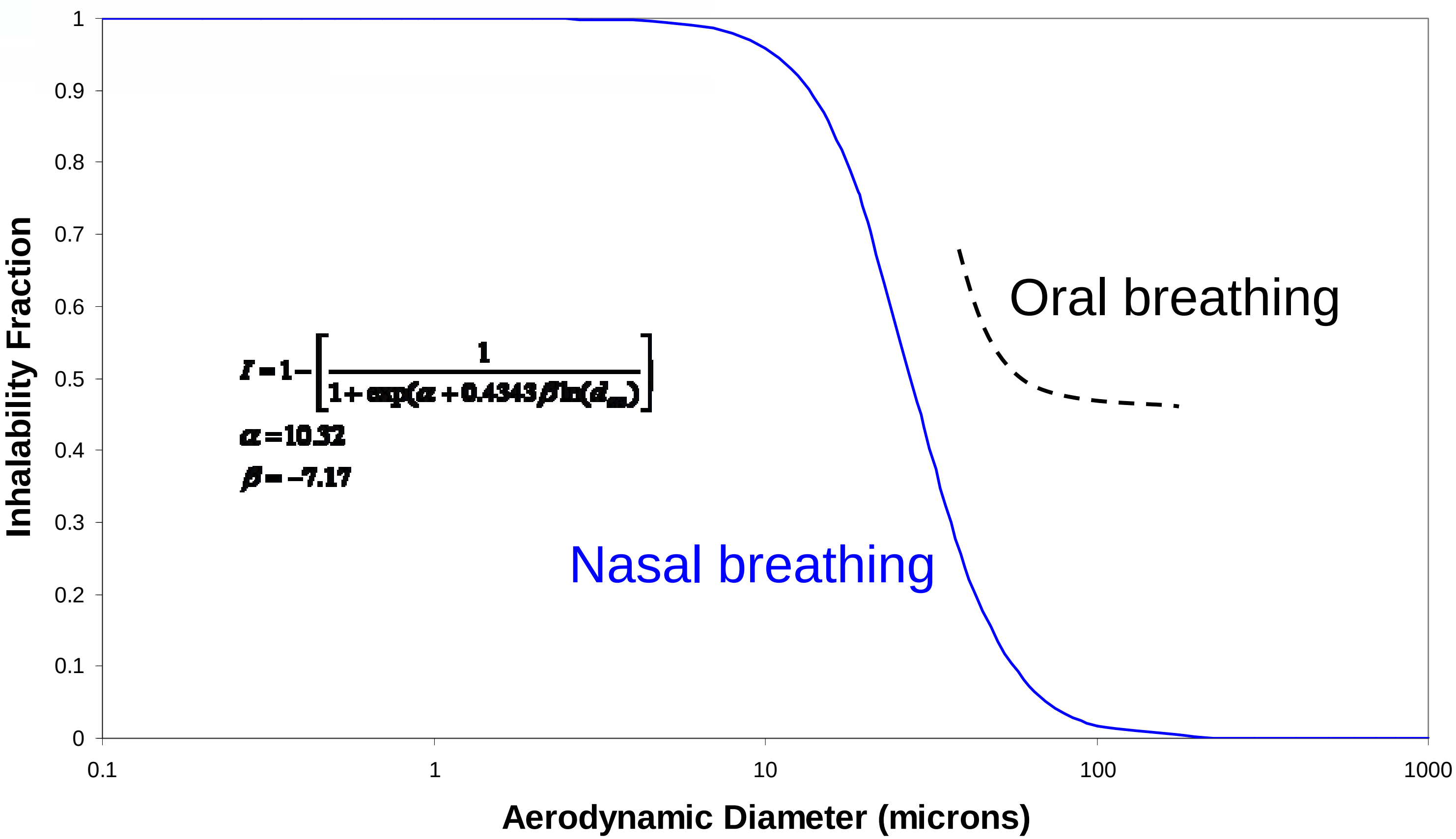
$$I(d_{ae}) = \frac{C_{inspired}(d_{ae})}{C_{ambient}(d_{ae})}$$



[1] Menache et al., 1995

[2] ICRP66, 1994

Inhalability Ratio Can Be Modeled[1]

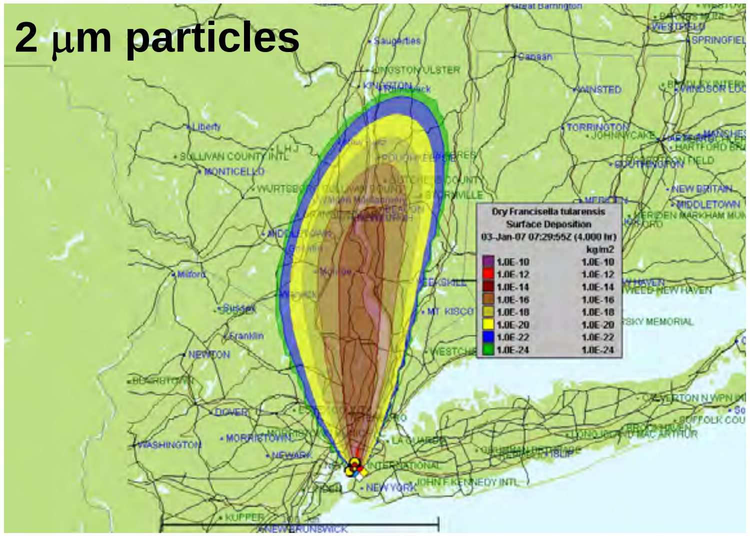


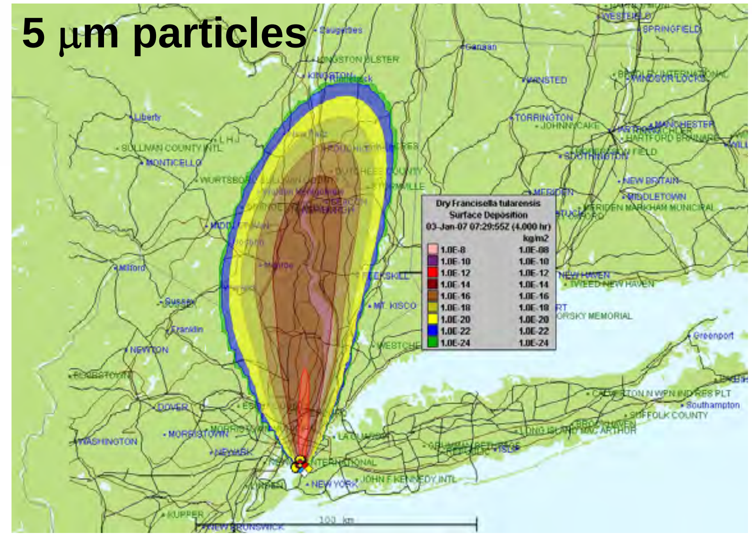
[1] Menache et al., 1995

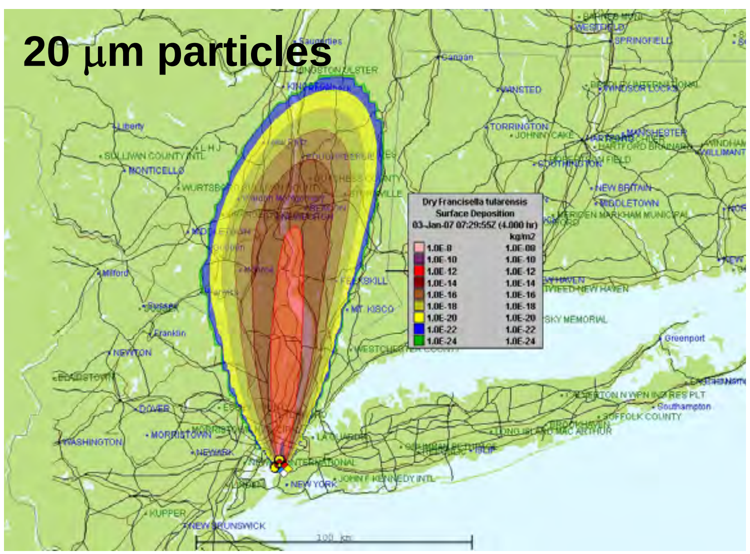
Particle Settling - HPAC Test Cases

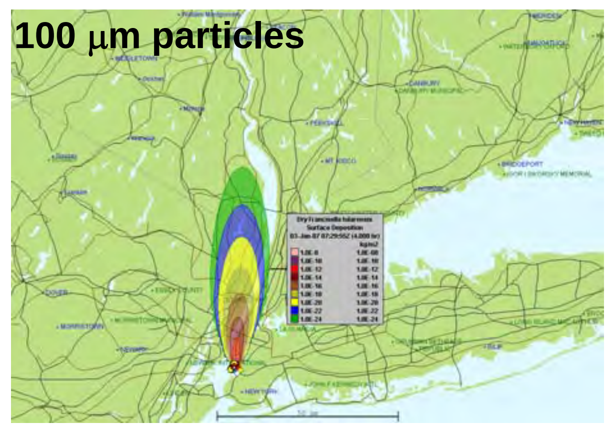
- *F. tularensis*, dry agent
- Missile with sub-munitions, close spread (10 m) to simulate single point release
- Particle sizes from 2, 5, 20, and100 microns
- Release mass fixed (1.6 kg dispersed)
- All releases at same location and time
- Historic winds

Surface Deposition @ 4hr

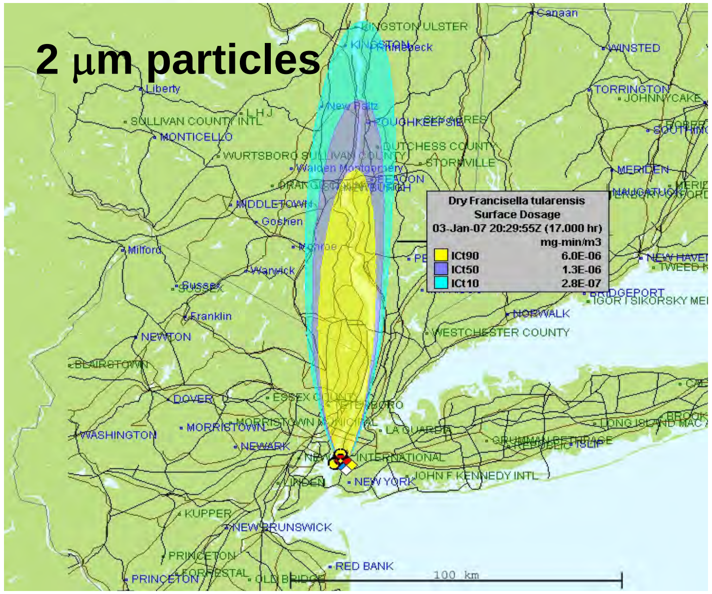


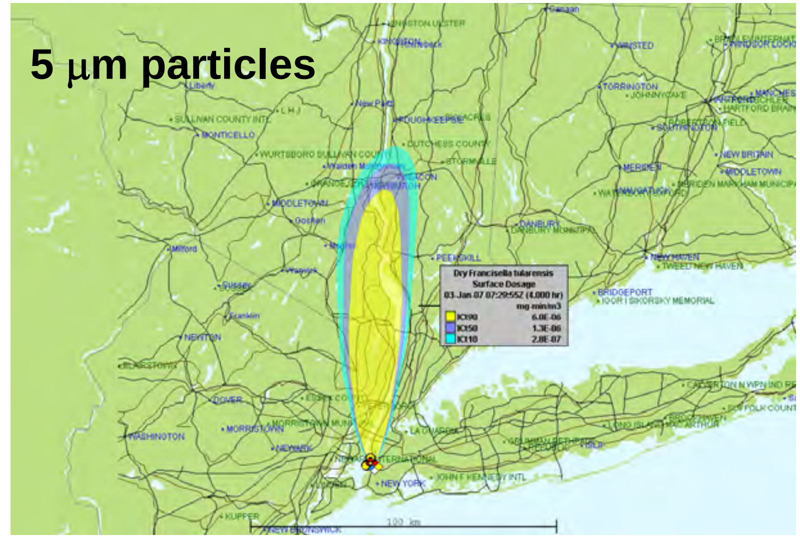


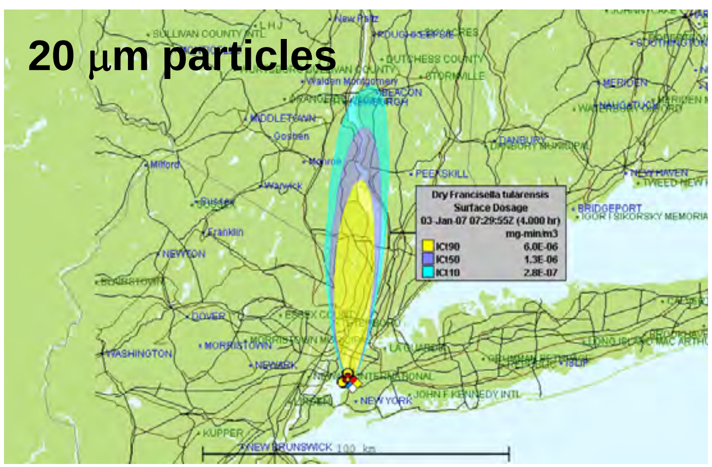


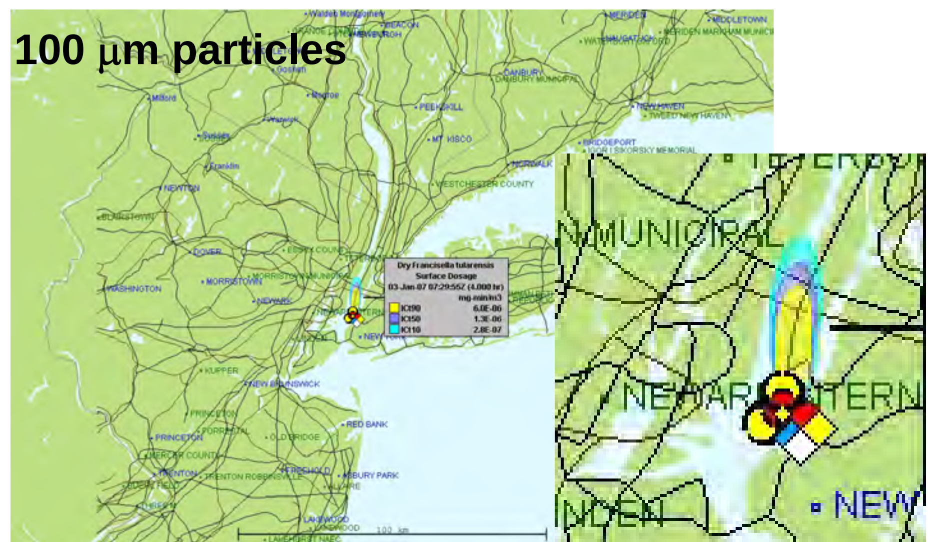


Surface Dosage @ 4 Hours









Inhalation and Biokinetics of Aerosols

- Deposition
  - Physical processes
  - Anatomy
  - Breathing mode
- Dissolution-absorption-colony formation
- Clearance

Physical Characteristics of Particles Affect Deposition Processes

- Deposition processes

- Physical characteristics
  - Aerodynamic size
  - Particle shape
  - Hygroscopicity
  - Electrical charge

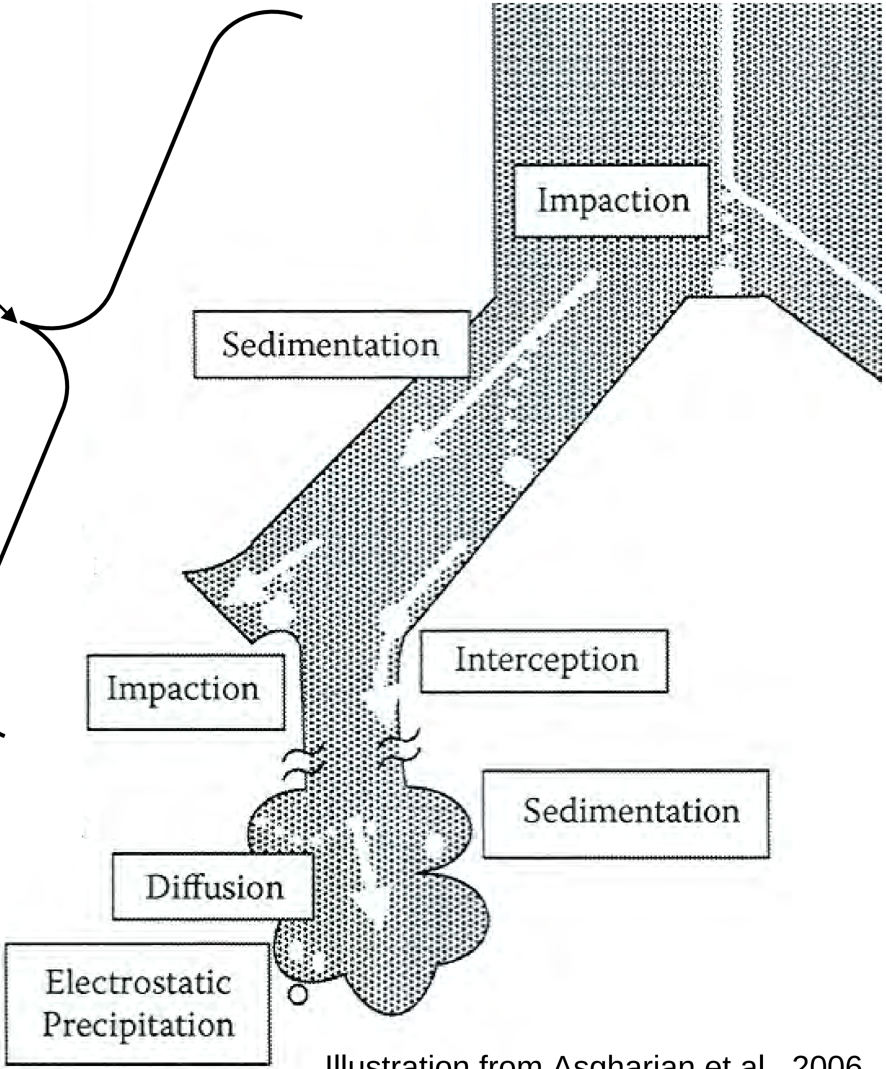


Illustration from Asgharian et al., 2006.

Respiratory Tract Anatomy and Geometry Influence Deposition

- Physical structure
  - Airway diameters
  - Branching patterns
  - Path length to alveoli
  - Structural dynamics
  - Response to biological or chemical stimuli
  - Inflammatory response
- Intersubject variability
- Breathing mode
  - Nasal
  - Oral

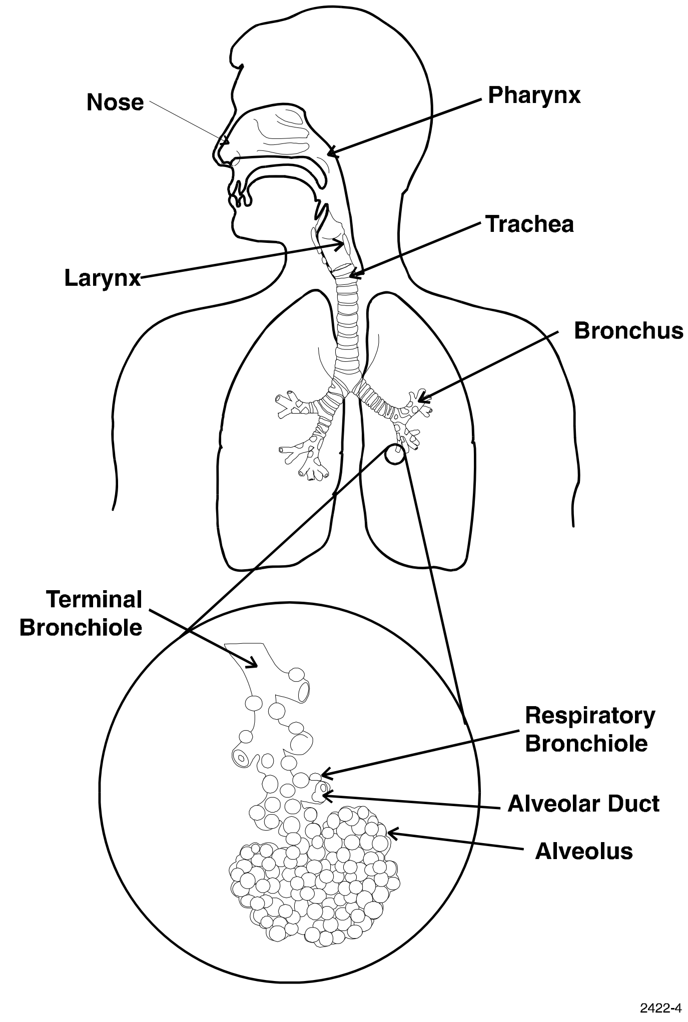


Illustration from ????.

Breathing Mode Has Major Impact on Particle Deposition Pattern

- Nasal breathing
  - Convoluted airways
  - Filter large and small
- Oral breathing
  - Increases TB and P exposure
  - Raises inhalability of larger particles
- Oronasal breathing
  - Linear combination
  - Varies with exertion

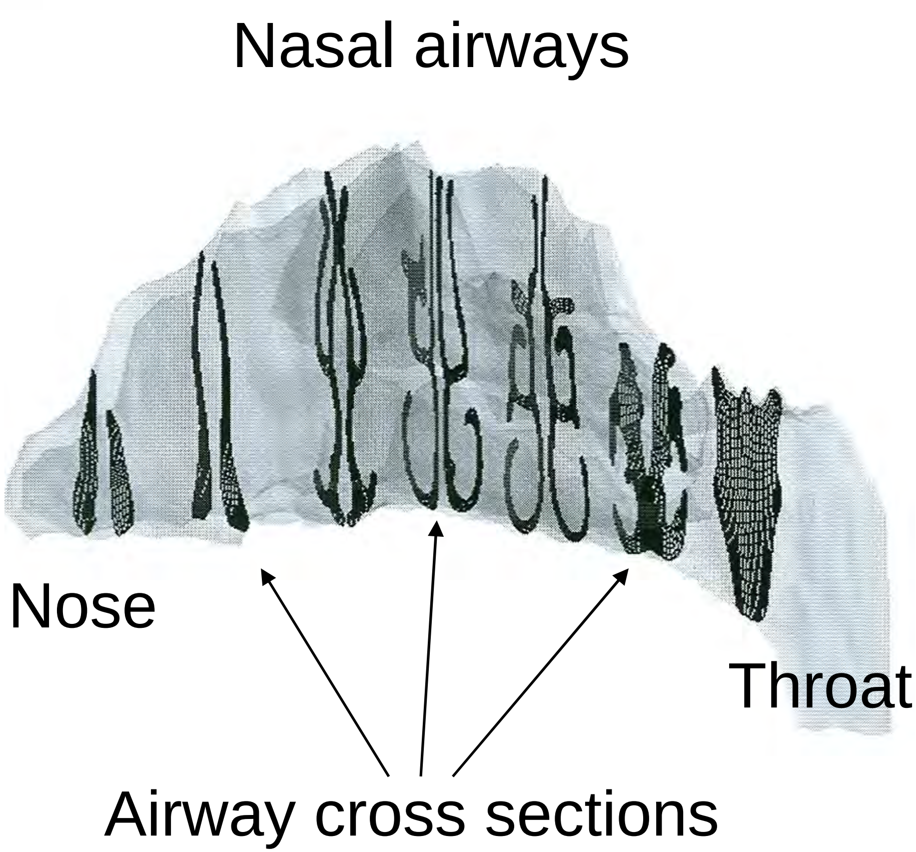


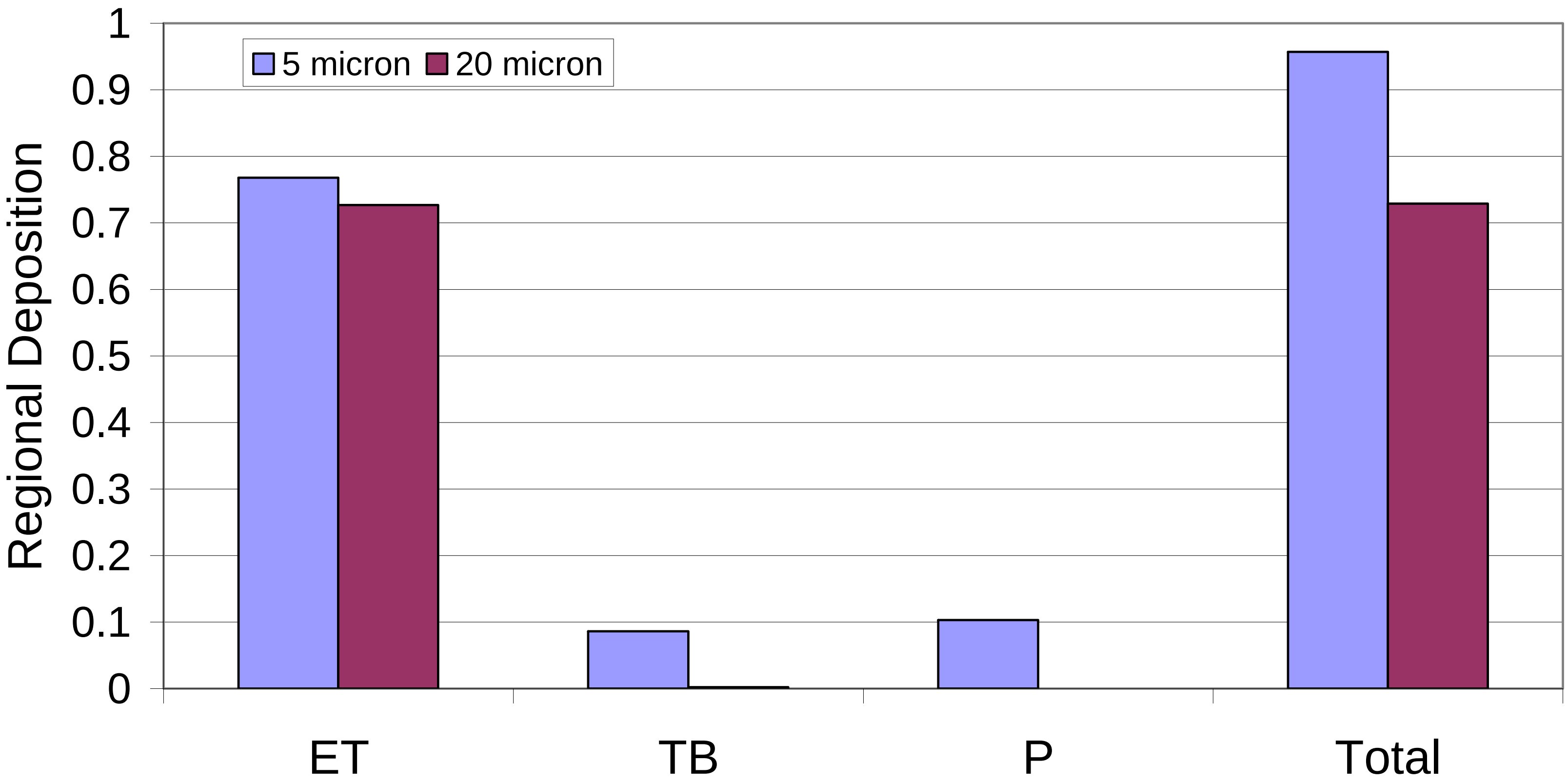
Illustration from Asgharian et al., 2006.

Clearance After Depostion

- Physical clearance
  - ET
    - Mostly swallowed
    - Some by blowing nose
  - TB
    - Mucociliary “elevator” → swallowed
    - 24 – 48 h clearance time
  - Pulmonary
    - Collection by macrophages
    - Slow clearance; months…
- Dissolution-absorption
  - Dependent on physical and chemical properties

Calculated Deposition for Humans Correlates With The Tularemia Data for Monkeys

Nasal Breathing
(Inhalability Factor Included)



Deposition calculated with MPPD (Asgharian et al., 2001).

Conclusion

- “Standard-sized” particles (3-5m) are most efficient as inhalation hazards
- Larger particles (10-25m) are quite effective for some agents, but not for all
- Medical outcome depends on particle size
  - Data shown for tularemia, ricin
  - Data exist for plague, anthrax, SEB, Q fever, brucellosis, and botulism
- Particle size-dependent effects can and should be included in medical modeling and simulation

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NCEP Meteorological Model Predictions for Dispersion Applications

Jeff McQueen, Dusan Jovic, Binbin Zhou, Marina Tsidulko, Sundara Gopalakrishnan, Jun Du and Geoff DiMego

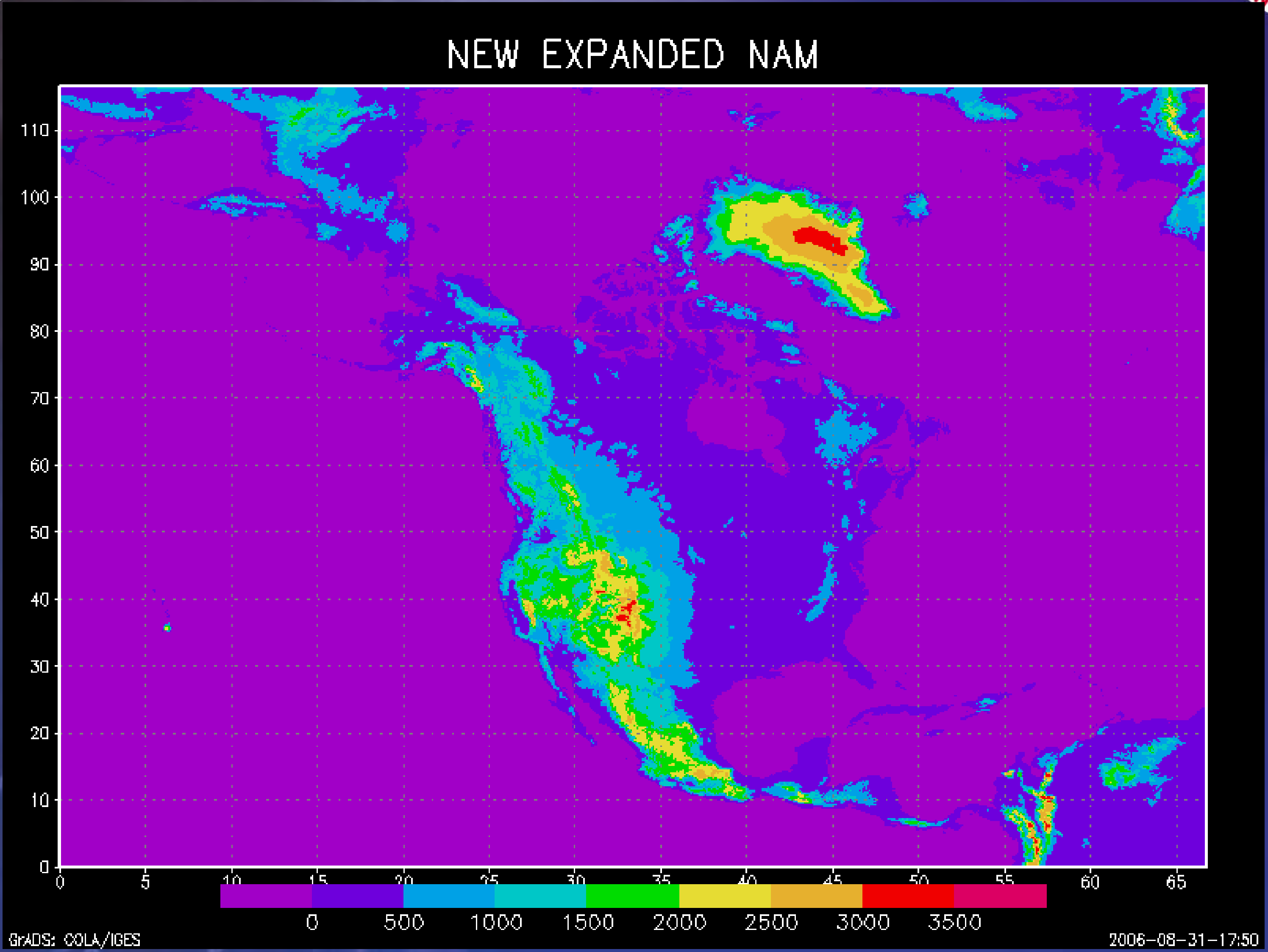
NOAA/NWS
National Centers for Environmental Prediction
Environmental Modeling Center

March 30, 2007

National Centers for Environmental Prediction (NCEP)

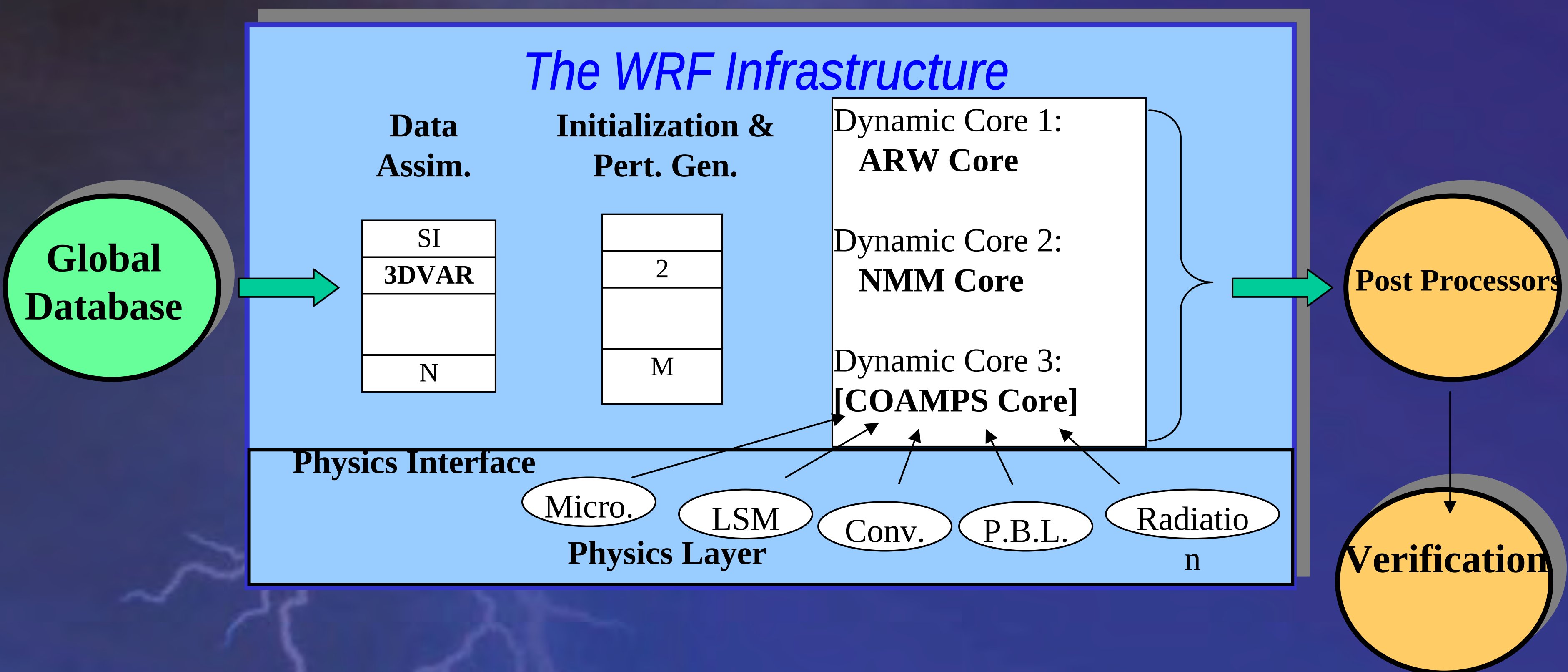
- **Among the Nation's leaders in providing global and national climate and weather analysis, forecasts and guidance**
- **Develop and Improve numerical weather, climate, hydrological, space and ocean prediction systems**
- **Applied research in data analysis, modeling and product development**

North American Model (NAM-WRF)



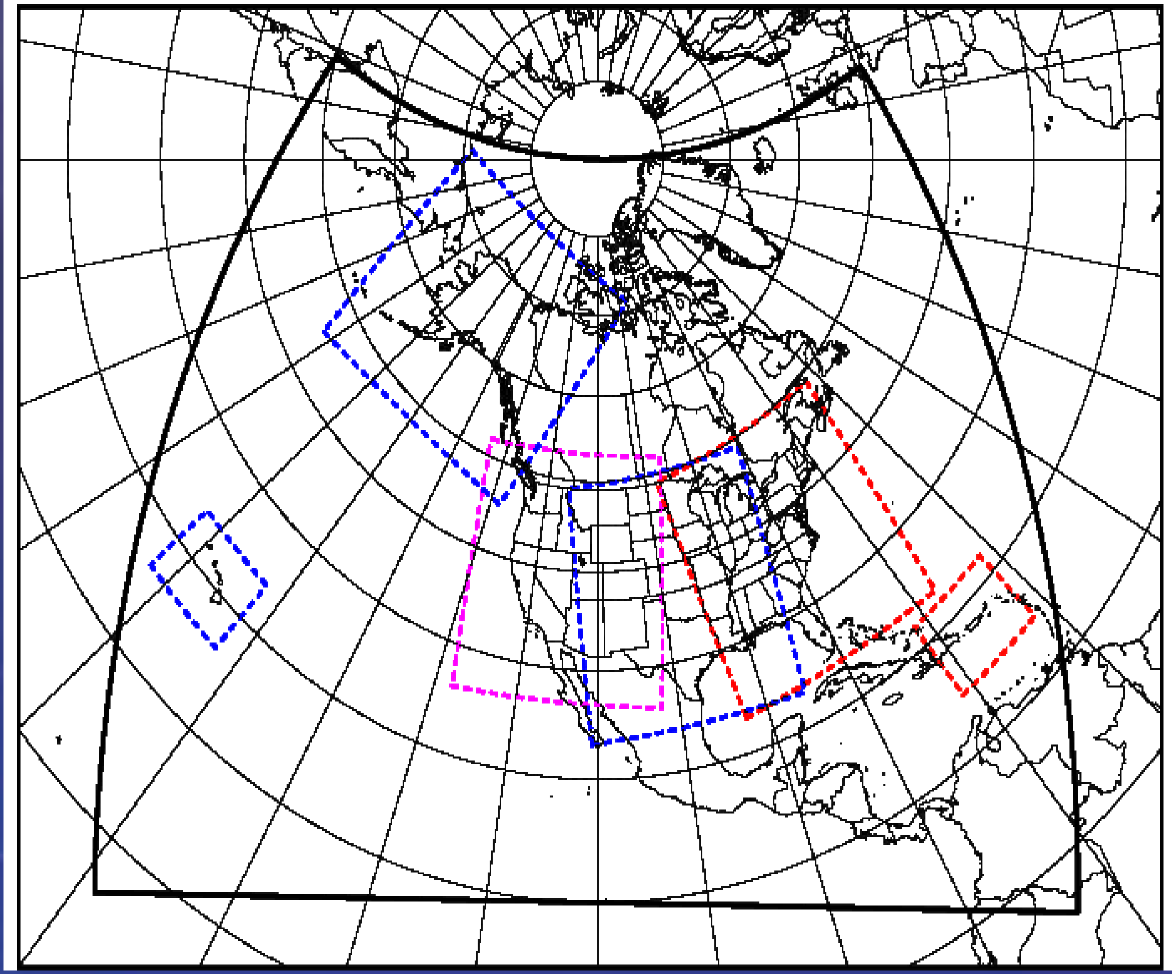
North American Model (NAM) WRF run 4x/day at 12 km to 84 hours

Weather Research and Forecast (WRF) System



HiResWindow Fixed-Domain Nested Runs

- FOUR routine runs made at the same time every day (5 km)
- 00Z : Alaska & Hawaii
- 06Z : Western & Puerto Rico
- 12Z : Central & Hawaii
- 18Z : Eastern & Puerto Rico
- Everyone gets daily high resolution runs *if & only if* hurricane runs are not needed



http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/

Global Forecast System

Run Slot #/day	Mission & (Notes)	F Hrs	Resolution (hor/ver)
Global Forecast System (GFS) **4/day**	▪**Global general weather and aviation guidance to 15 days (winds, temp, rainfall)** ▪**Boundary + initial conditions for NAM, Ocean models** ▪**Initial conditions for ensemble generation** ▪**Supports Model Output Statistics** ▪**Hurricane tracks**	**384 hr**	✓**35 km/ 64l** ✓**55 km/ 42l after 84 hr** ✓**75 km/28l beyond 180 hr**
Global Data Assimilation System (GDAS) **4/day**	▪**Provides best guess for GFS analysis, verification & validation** **3-D Variational 6-hr update frequency with digital filter**	**9 hr with 6 hr update**	**35 km/ 64l**
Global Ensemble ***4/day***	▪***Probabilistic rainfall (QPF) and general weather to 15 days*** ***14 members with initial condition perturbations generated from Ensemble Transform Technique***	***360 hr***	✓***100km/28l***

Additional NCEP Models with applications for AT&D

- **On-Demand Homeland Security Nests**
  - *On-demand real-time High Resolution WRF 4km Grid Runs*
  - *26 pre-defined nests*
  - *NOAA responsible for met. model CONUS predictions*

- **Rapid Refresh WRF**
  - *13 km CONUS hourly analyses to 18 forecast hours*

- **Real-Time Mesoscale Analysis system (RTMA)**
  - *2-D Variable data assimilation at the surface*
  - *hourly analyses at 5 km resolution*

- **Analysis Of Record**
  - *Downscaled from NDAS analysis to provide high resolution climatology than 32 km Regional Reanalyses*

- **WRF-CMAQ Air Quality Forecasts (O3 / PM)**
  - *CONUS 12 km 48 hour forecasts 2x/day*

Provision of Additional Products

- **NCEP Products to DTRA-MDS**
  - ***Global Forecast System ½ degree 3 hrly predictions to 16 days***
  - ***Global Ensemble Mean and Spread files to 16 days***
  - ***Short Range Ensemble to 84 hours (4x/day)***
  - ***NAM-WRF high resolution 12 km CONUS and North American grids***

WRF Output to improve HPAC coupling

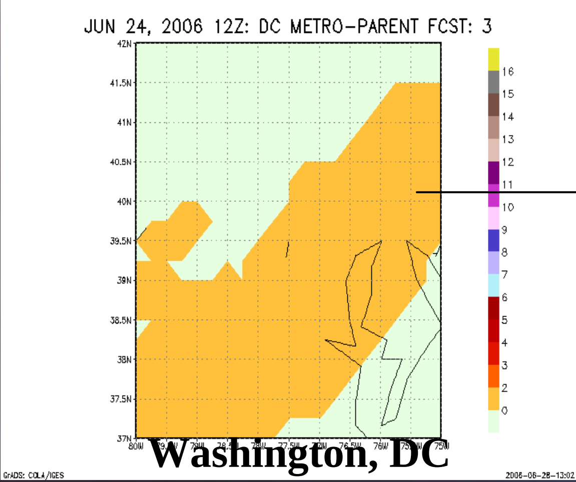
- **Instantaneous and *time-averaged* surface sensible heat, latent heat, and momentum fluxes**
- **Roughness length, vegetation types and fraction**
- **Shelter level, skin, and soil temperature, moisture, and wind**
- **Cloud fraction**
- **Mixing length**
- **3 D Wind, temperature, and specific humidity**
- **3 D Turbulent Kinetic Energy**
- **3 D eddy diffusivity of heat**
- **PBL height**
- *Time-averaged winds, TKE and mixing lengths*
- *Eddy energy dissipation rates*
- *3-D eddy diffusivity of momentum*
- ***3-D wind variance from ensemble***
- *Large Scale Variance proportional to wind variance ?*

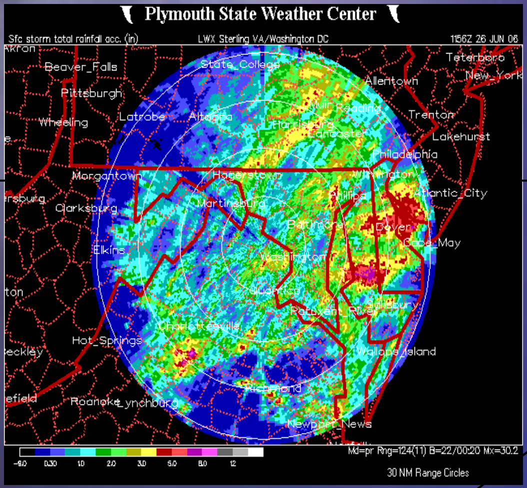
NCEP AT&D Focus for HPAC

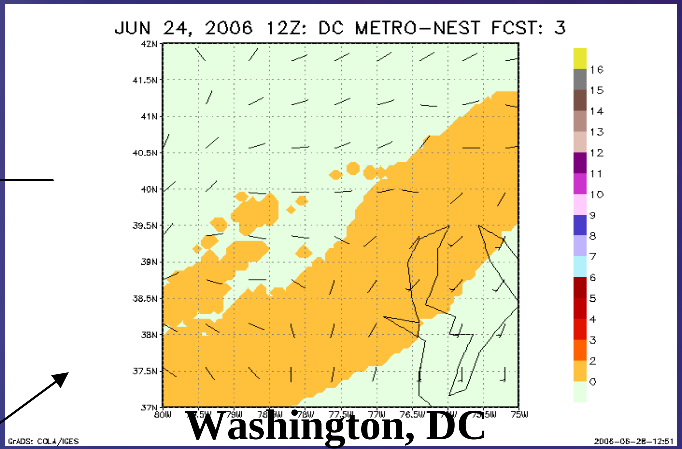
- **Improved Coupling of Mesoscale Models w/ HPAC**
  - *Special real-time High Resolution Nested Grid Runs (eg: Torino Olympics)*
  - *Additional turbulence Fields output to NCEP GRIB files and to DTRA servers*
  - *Evaluation of WRF turbulence characteristics with PSU & Hanna Consultant.*
  - *Development of a real-time PBL height and cloud cover verification system*

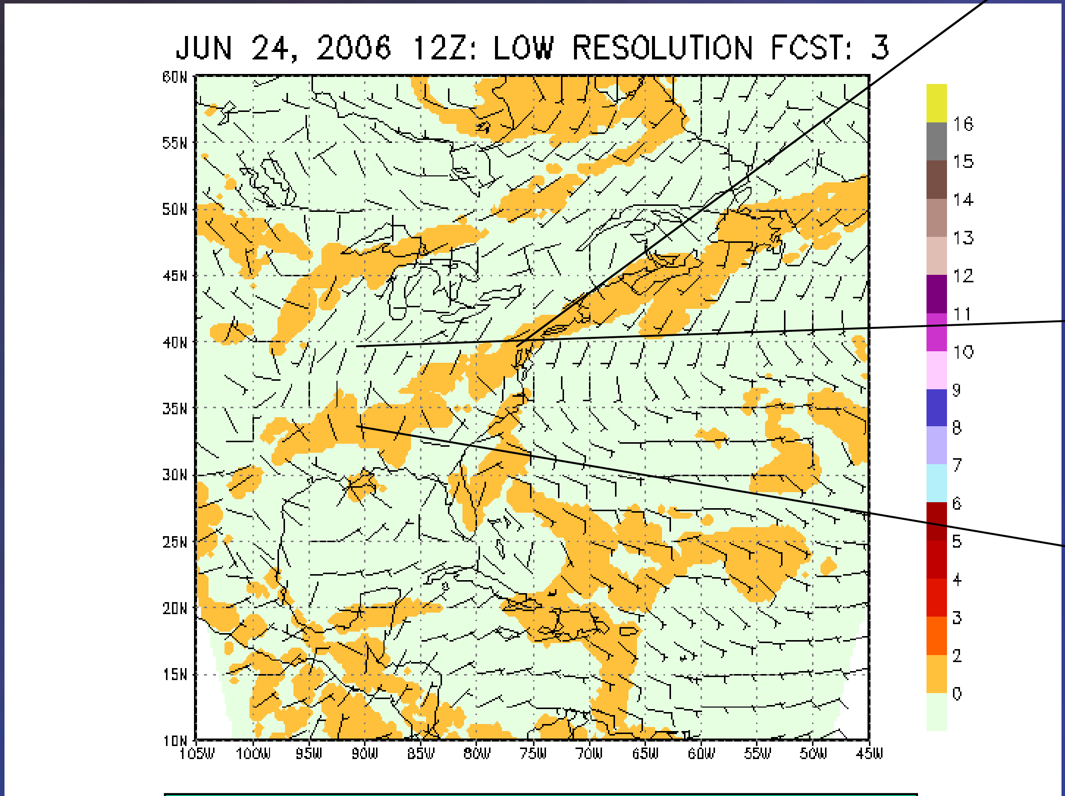
- **Development and Testing of a High Resolution Ensemble Prediction Systems**
  - *NCEP WRF ensemble breeding system for initial condition diversity*
  - *Uses both ARW and NMM cores and physics suites*
  - *Began testing a 10 member WRF HREF*
  - *Providing experimental ensemble wind variance fields needed to drive HPAC uncertainty calculations*

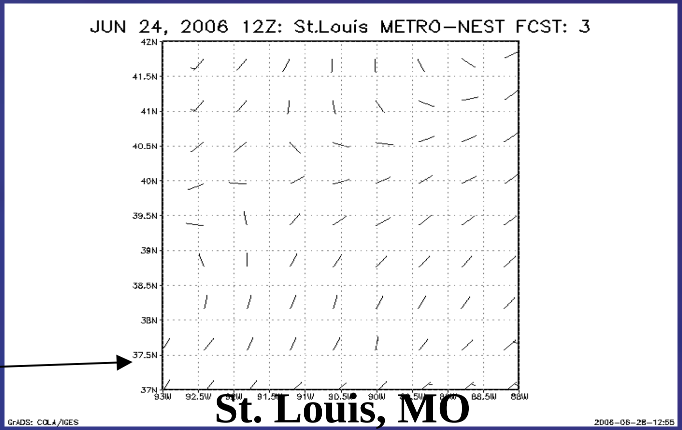
- **Incorporation of probabilistic verification for Ensemble System evaluation**
  - *Deterministic FVS developments: pbl hgt & cloud cover verification*
  - *Probabillistic: Ranked Histograms, spread, statistical consistency, outlier diagrams added for ensemble verification*

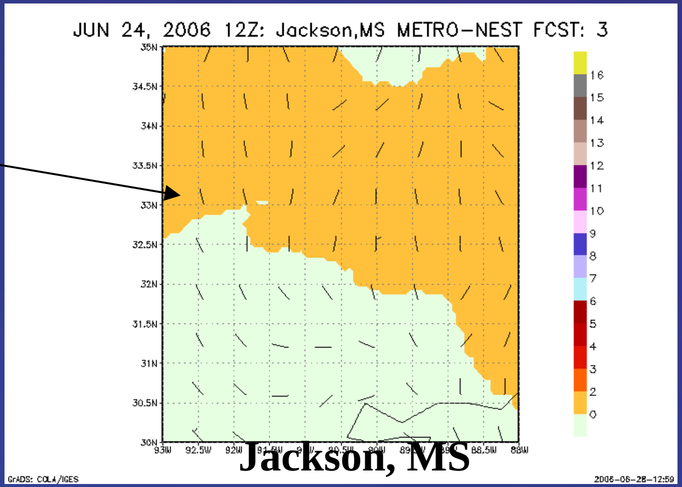












High Impact on-demand Nests

Torino Olympics

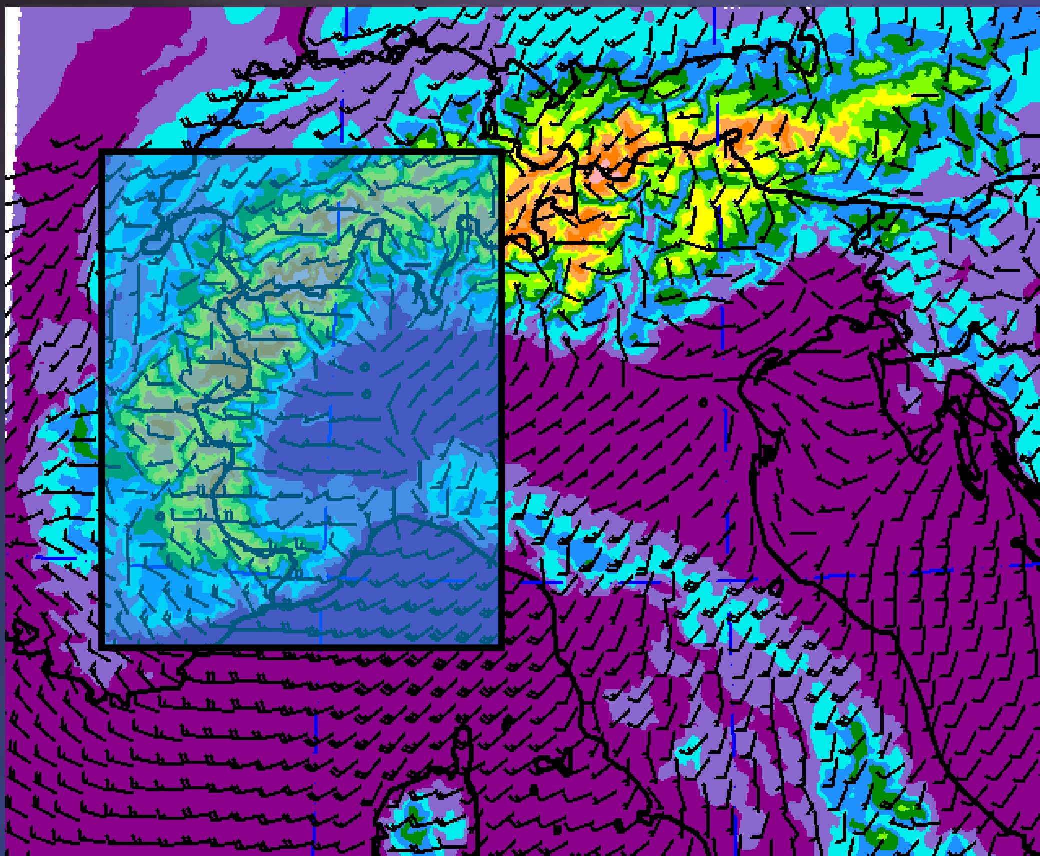
WRF nested runs (Dusan Jovic)

- WRF-NMM V2.1 using H-WRF nested grid configurations
- 24 h forecasts at 00 and 12 UTC
- 4 km Alps nest w/in 12 km Europe Domain
- 50 levels
- *90 mins w/ 64 IBM Processors*

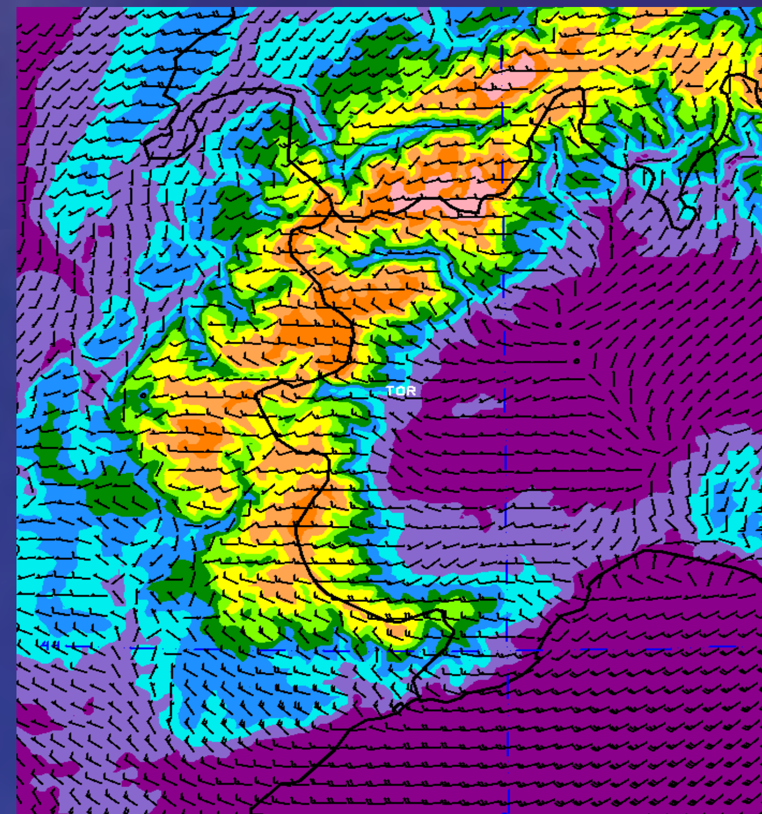
- Initialized with ½ degree GFS Pressure grids
- Ferrier Microphysics→ No convective Param.
- MYJ TKE, NOAH LSM

Torino Olympics

NCEP 4 km Domain



Full 4 km WRF Nested Grid Domain

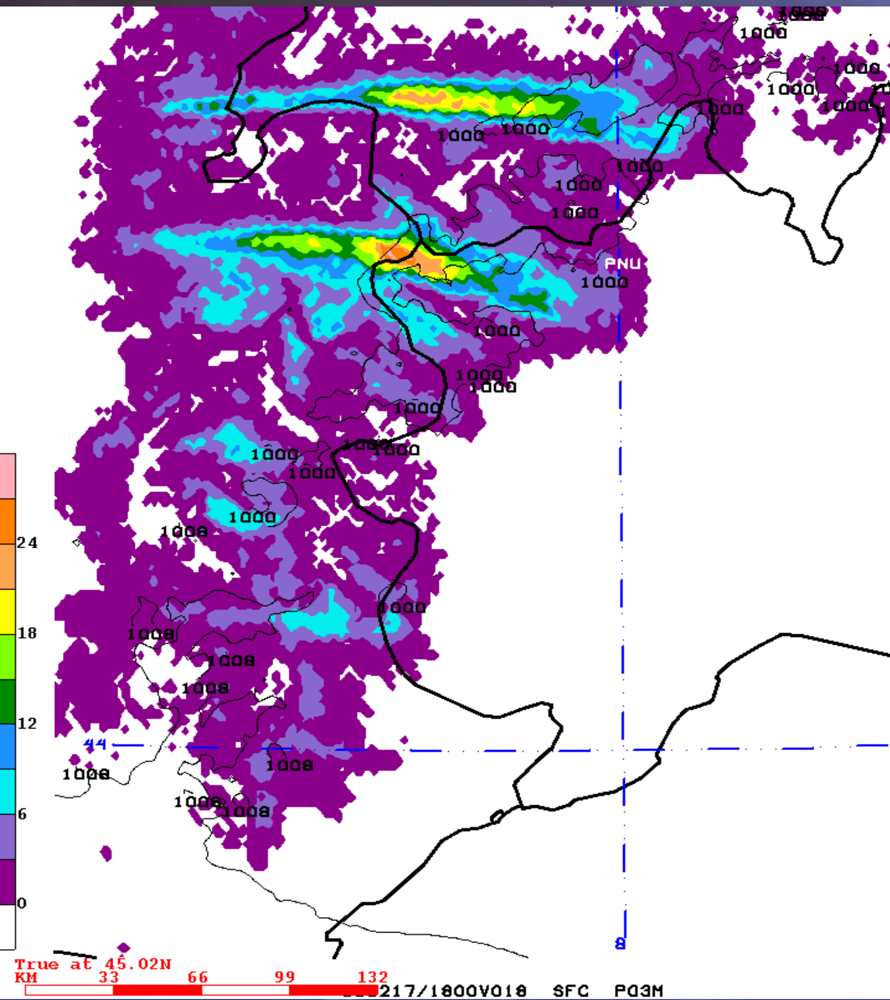


Zoomed view around Torino

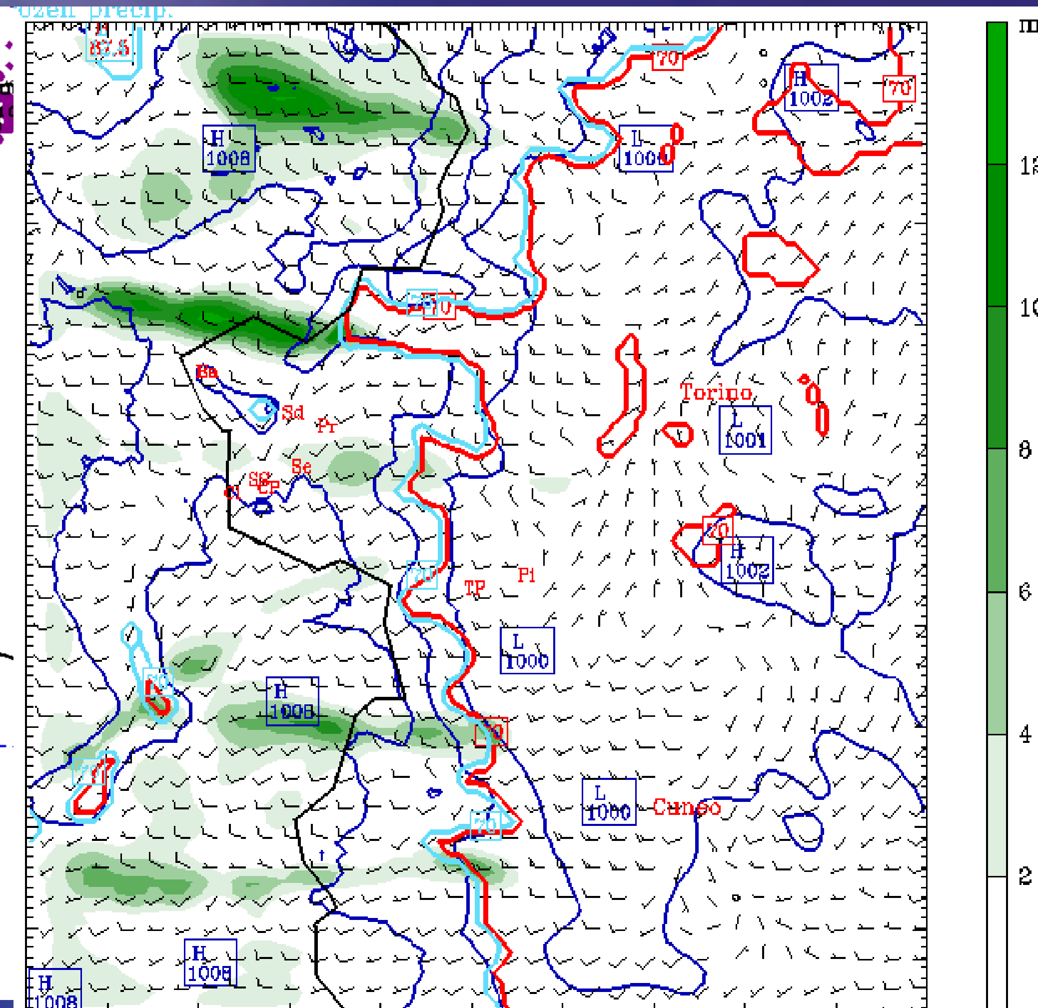
Torino Olympics

Snow Storm Forecasts (3h prcip)

00 UTC Feb. 17, 2006 18 h Forecasts



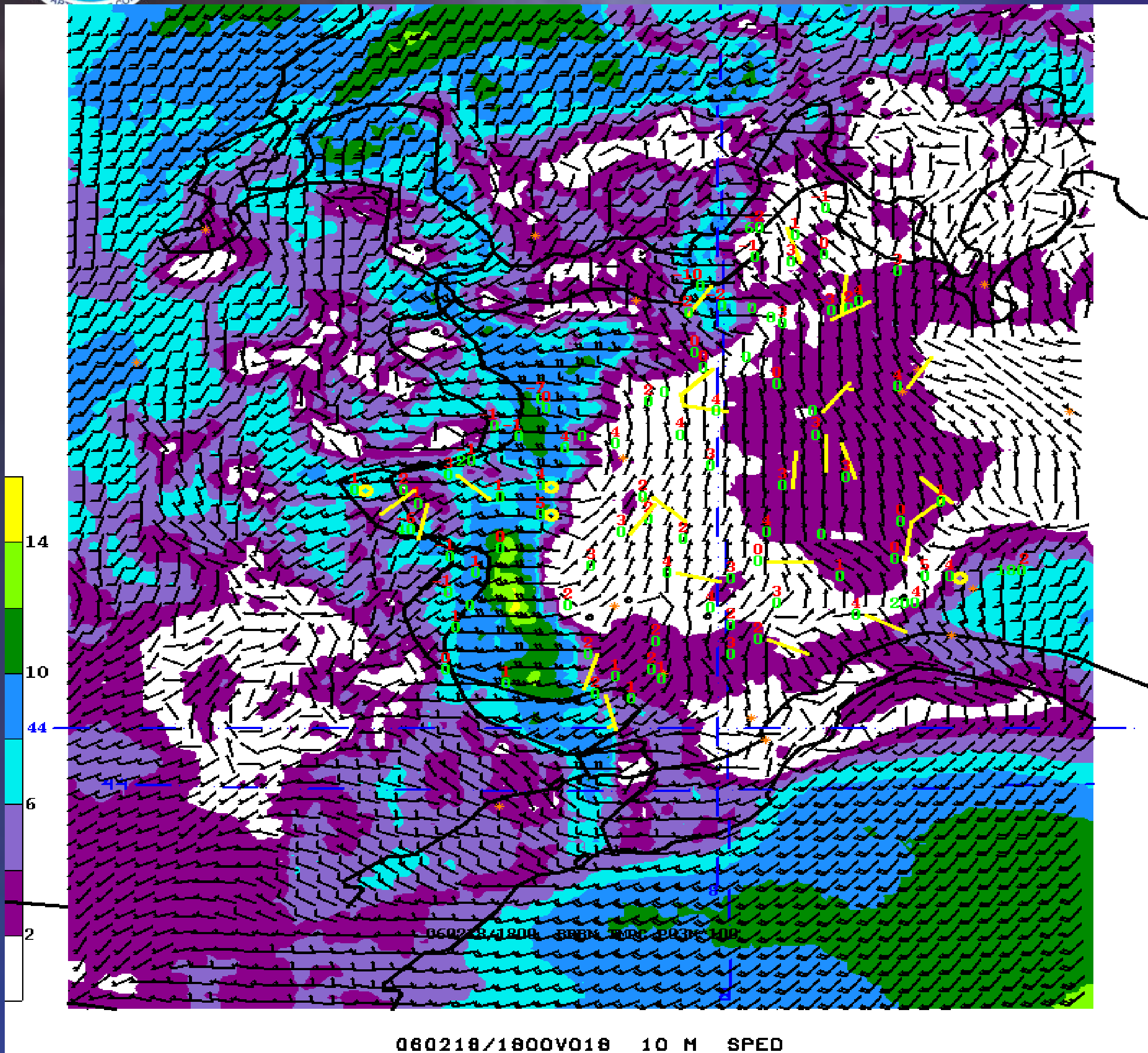
WRF-NMM 4km Zoom



MM5 4 km

Torino Olympics

February 18, 2006 case winds



Some down valley Flows captured

Mediterranean low is better captured in larger domain

Synoptic-orographic interactions are important

HPAC multi-model simulations

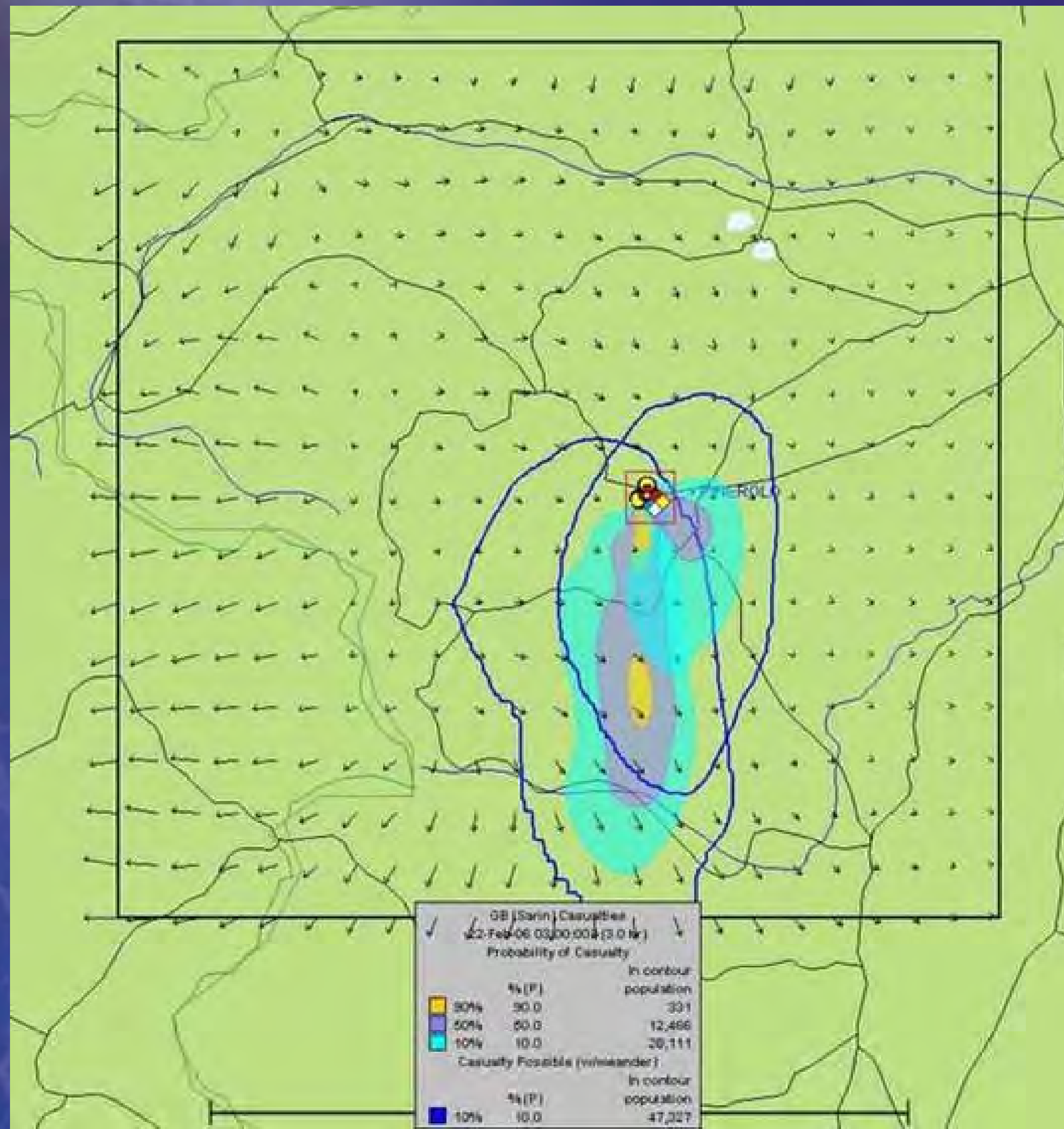
MM5 & WRF

- WRF & MM5 Plumes near Torino Olympics

- Blue lines: HPAC uncertainties w/ constant large scale variances

- Courtesy Pat Hayes, DTRA-NGC

Feb. 22, 00Z release (Case 5)



Short Range Ensemble Forecast

WRF members added to : 21 multi-model members

Run 4x/day to 84 hours (6 WRF, 10 Eta, 5 RSM)

Core	*3 NMM members*	*3 ARW members*
Horizontal	40km	45 km
Vertical	50 hybrid sigma-P levels	35 Mass levels
Adv/Physics Time Step Computer usage	110/600 sec (32 procs/member)	108/200 sec (40 procs/member)
Diffusion	Increased Smagorinsky deformation	Vertical damping
Physics	NOAH LSM MYJ TKE PBL BMJ Convection Ferrier Microphysics	NOAH LSM MRF 1^{st} order PBL Kain-Fritsch Convection Ferrier Microphysics

Ensemble Products to DTRA-MDS

Means/ Spread(uncertainties)

- Heights at 1000, 850, 700, 500, 250 mb
- U+V at 1000, 850, 700, 500, 250 mb & 10 m
- Temperature 850, 700, 500 mb & 2 m
- Dew Point (RH) 850, 700, 500 mb & 2 m
- QPF at 3, 6, 12 and 24 hour totals
- 12-hr Snowfall
- Sea Level Pressure
- Precipitable Water

Probabilistic Fields

- 3-hr/6-hr QPF — GE .01”, .25”, .50”, 1.0”
- 12-hr/24-hr QPF — GE 01”, .25”, .50”, 1.0”, 2.0”
- 12-hr Snowfall — GE 1”, 4”, 8”, 12” (have 2.5, 5, 10, 20”)
- Temperature at 2 m & 850 mb — LE 0^{o}C
- 10 m Wind — GE 25 kt, 34 kt, 50 kt
- CAPE — GE 500, 1000, 2000, 3000, 4000
- Lifted Index — LE 0, -4, -8
- Surface Visibility — LE 1 mi, 3 mi
- Cloud Ceiling* — LE 500 ft, 1000 ft, 3000 ft
- Probability of precipitation types (have rain, frozen, & freezing)
- 6-hr/12-hr/24-hr QPF Best Category

Ensemble Covariance Products

Daily ensemble products

Binbin Zhou, EMC

http://www.emc.ncep.noaa.gov/mmb/SREF_avia/TEST/web/html/variance.html

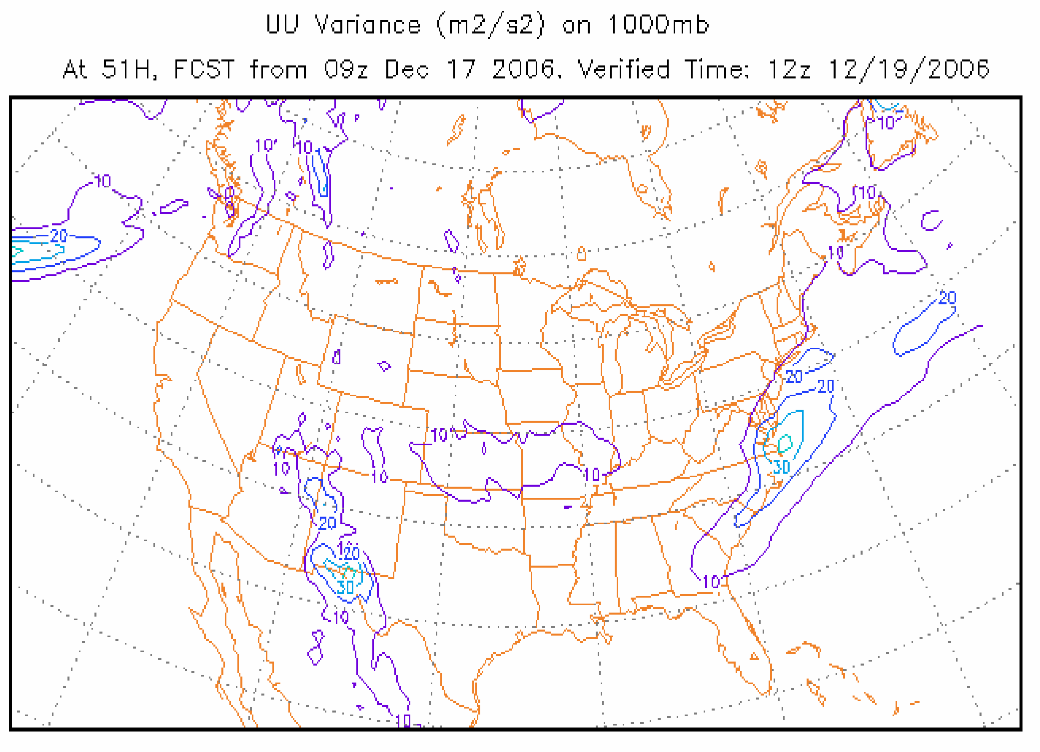
EKE=0.5*(UUE+VVE+WWE)

$$UUE = 1/N \sum^{N} (U^{m}_{ij} - U_{ij})^2$$

$$VVE = 1/N \sum^{N} (V^{m}_{ij} - V_{ij})^2$$

$$UVE = 1/N \sum^{N} (U^{m}_{ij} - U_{ij})^2 (V^{m}_{ij} - V_{ij})^2$$

$$WWE = 1/N \sum^{N} (W^{m}_{ij} - W_{ij})^2$$



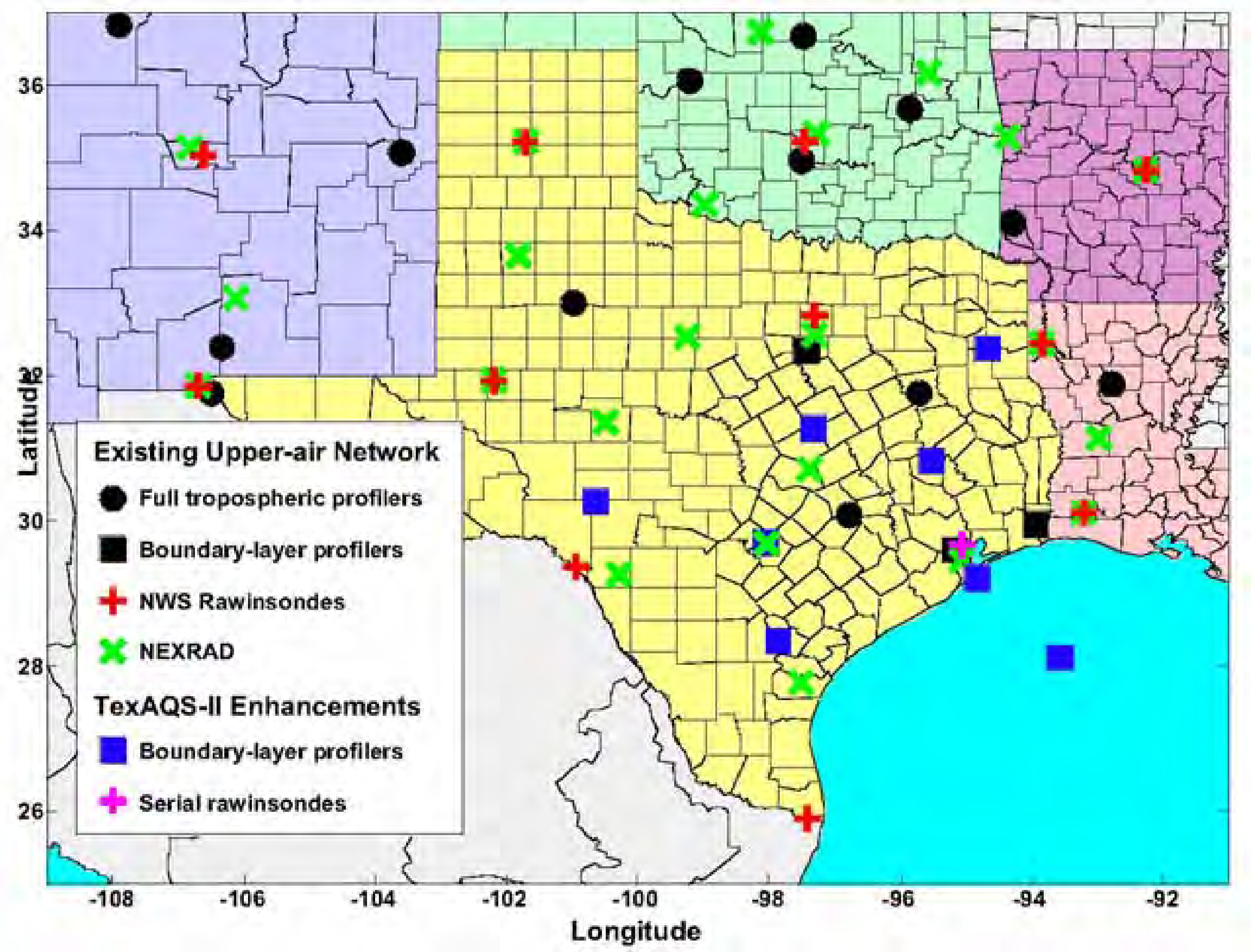
Ensemble mean sensible heat flux
Ensemble mean latent heat flux
U and V spread

NCEP's FVS Verification System

- **Input observations are from NCEP operational PREPBUFR files which include 1) radiosonde & dropsonde Z, temp, wind & moisture; 2) surface land & marine P, temp, wind, moisture observations; 3) ACARS & conventional aircraft wind, temp [moisture], and 4) Profiler winds.**
- **Verified Fields include *temperature, wind and moisture fields on pressure and shelter levels.***
- **Recently added *sensible weather (eg: Visibility) , wind shear, and PBL height***
- **Grid verification *of cloud cover using AFWA cloud cover products***

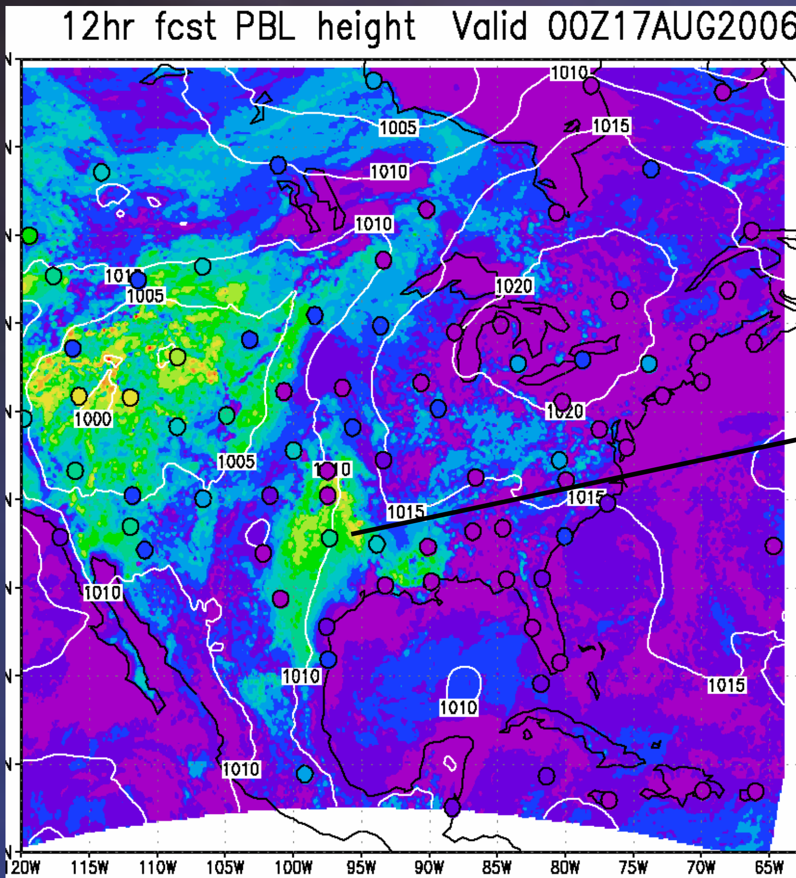
New FVS On-line System
Web-based MYSQL Database

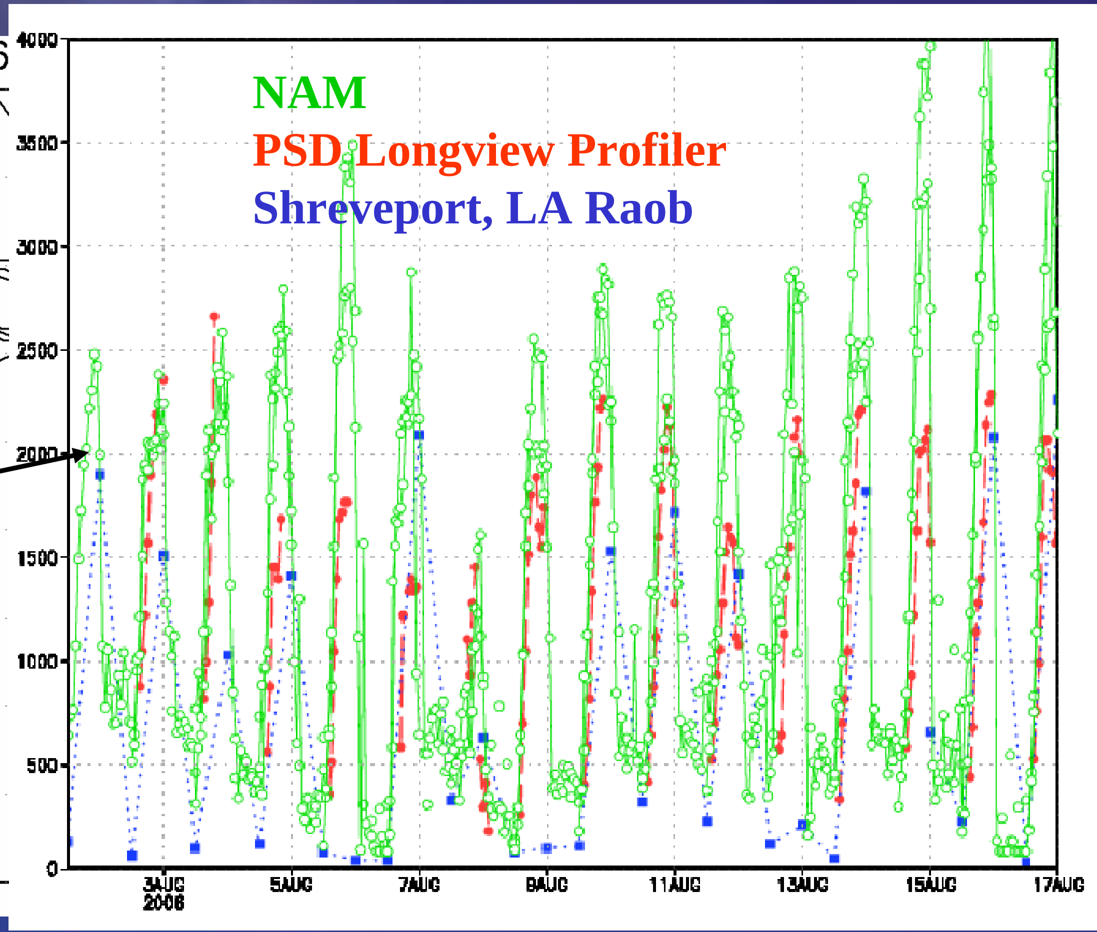
Texas Air Quality Experiment
Aug-Oct 2006



NAM PBL evaluation

using TEXAQS06 profilers





Statistical Consistency (August 2006)

48 hour Forecast Winds

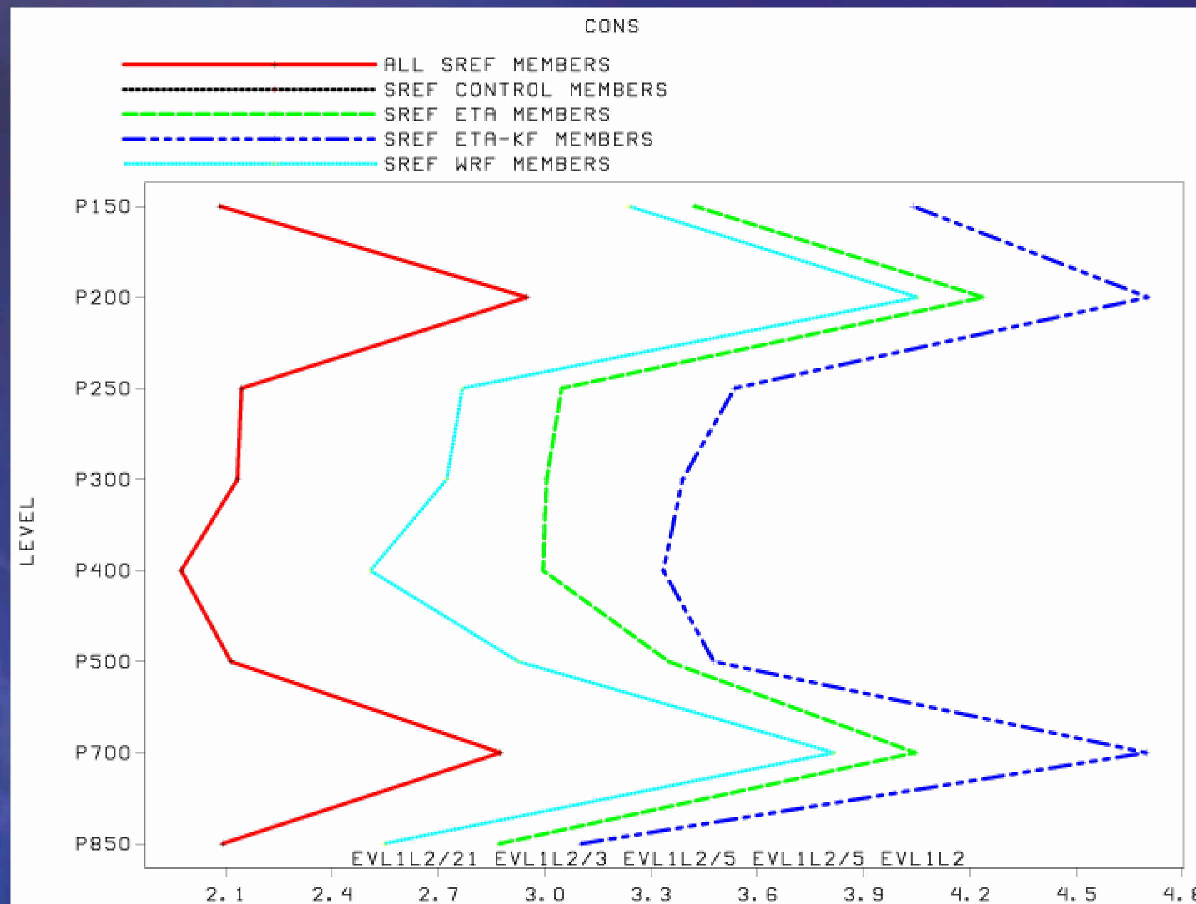
SREF-21 | Eta-KF
SREF-CTL | WRF
ETA-BMJ

Mean Squared Error
Ensemble Variance

best ~ 1 (Buizza, et al. 1999)

- ***SREF-21 improved***

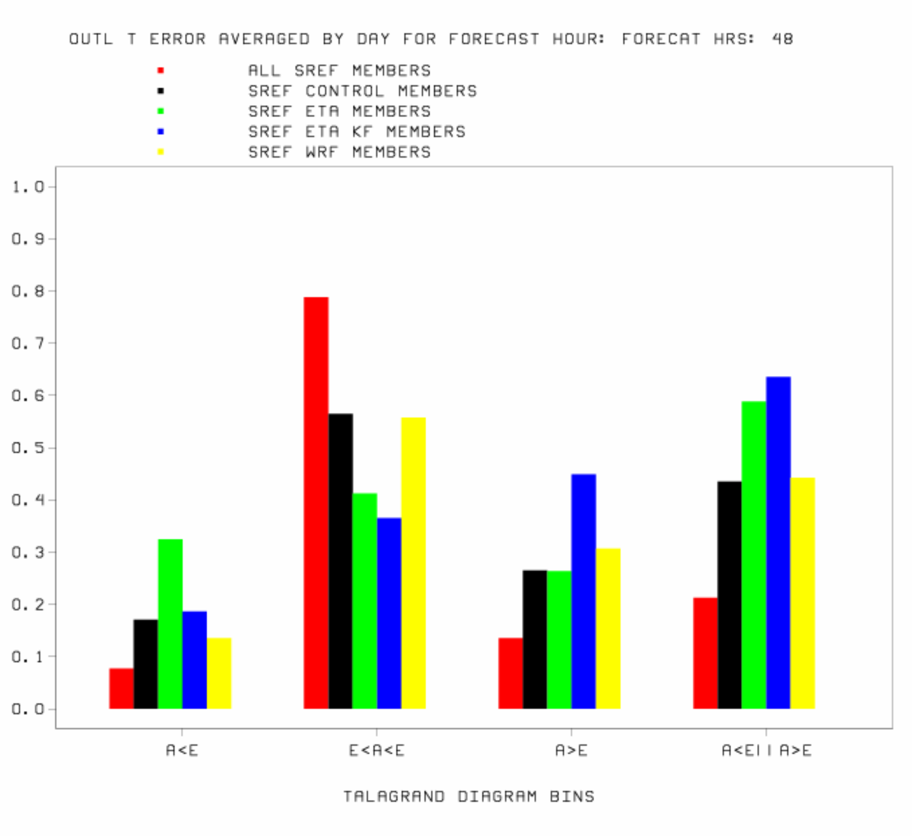
- ***WRF subset yields lowest statistical consistency compared to Eta subsets***

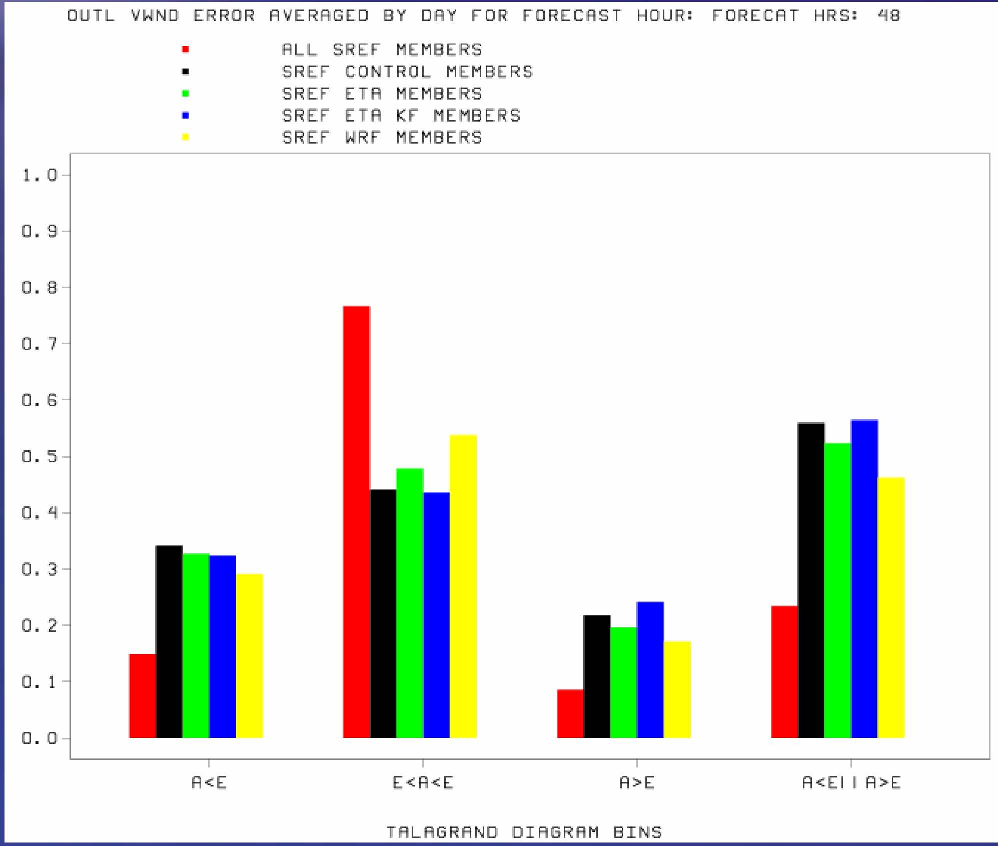


SREF Operational Performance

Outlier Percentage

48 h forecasts (August 2006)





2 m Temperature

10 m Wind

- *Outlier percentage reduced for SREF/21 system*
- *WRF sub-member agree best w/ obs as compared to Eta and RSM sub-members*

Met. Ensembles For ATD

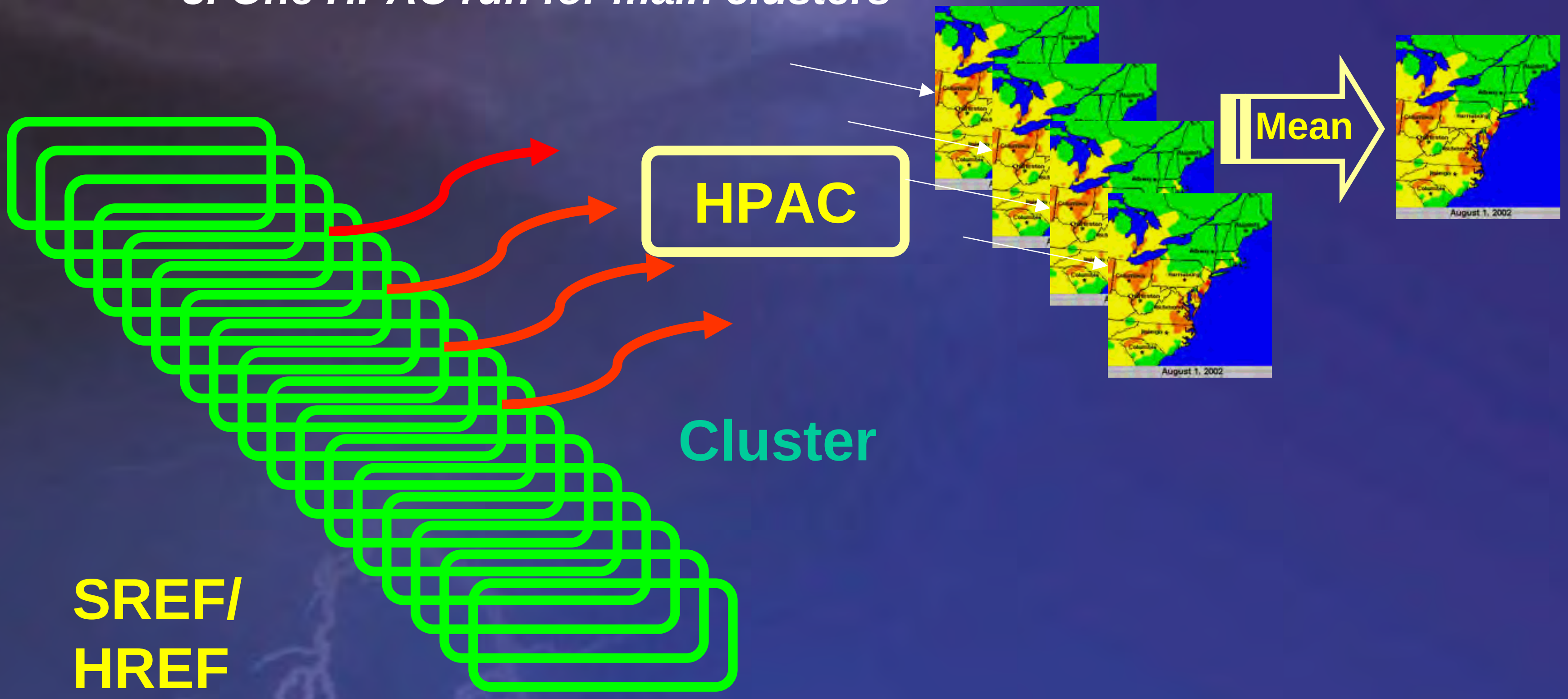
- **For ATD: physics perturbation techniques are promising**
  - *PBL parameterization*
  - *Land Surface Model specifications*
  - *Convective parameterizations*
  - *Stochastic physics efforts*

- **Will also need IC perturbations esp. for strong synoptically forced events**

- **Postprocessing**
  - *Bias correct winds, temp, rh, precip*
  - *Use ensemble wind variance as estimate of LSV (Wind error correlated with Wind variance, Coielle, 2005)*
  - *Reforecasting Project*
  - *Cluster ensemble members to drive Scipuff most likely scenarios (COSMO-LEPS approach)*

Dispersion Ensemble Configurations

1. One HPAC run (Ens. Median/variance)
2. One HPAC run for each member
3. One HPAC run for main clusters

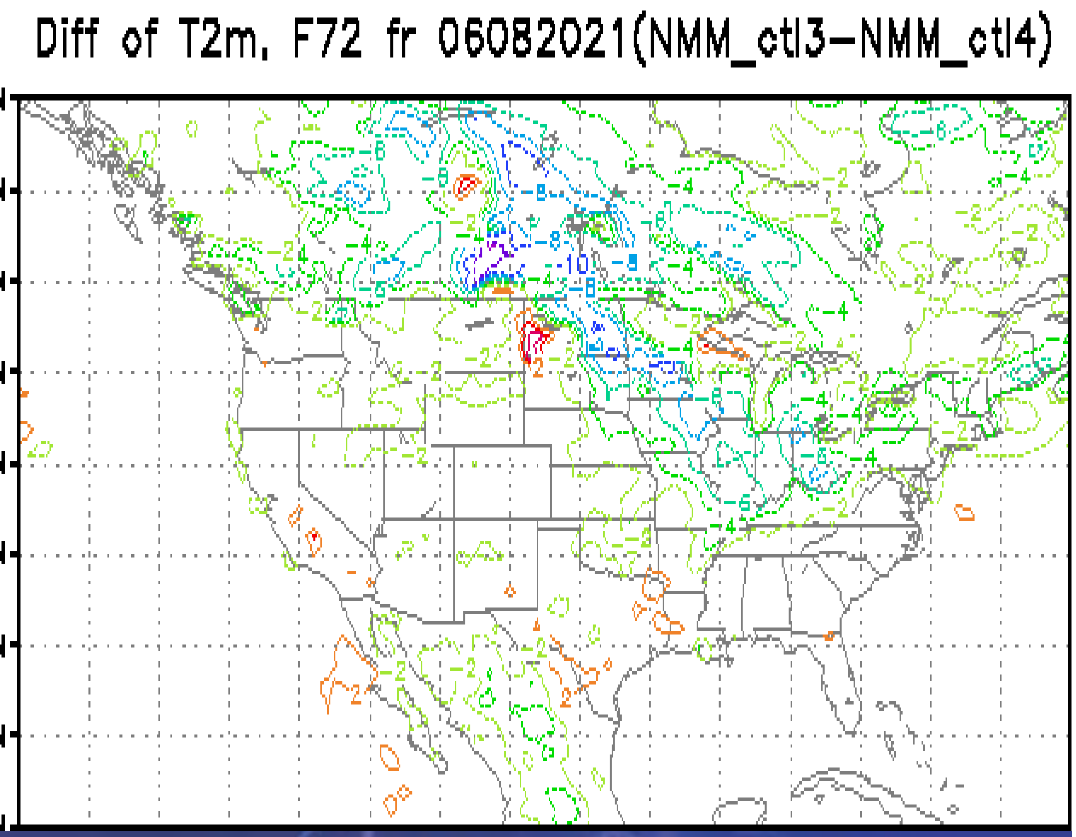


Cluster analysis can chose a smaller set of members statistically different from one another that correspond to the daily weather pattern.

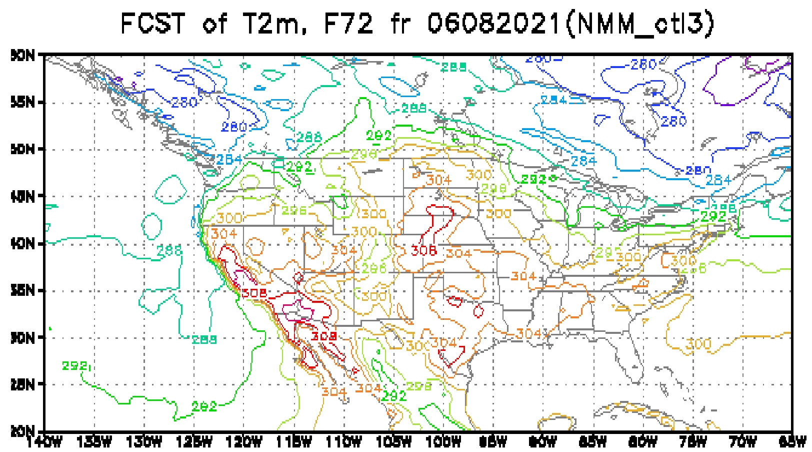
Soil Moisture Perturbations

Impact on T2m is significant

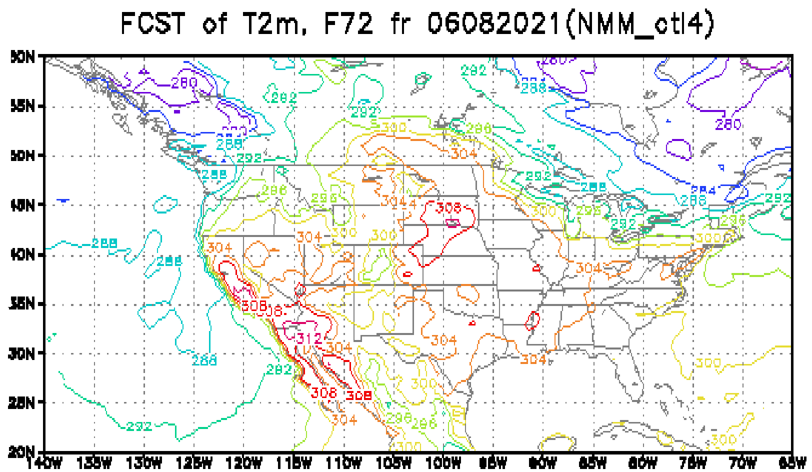
Jun Du & George Gayno



T2m diff (namSM – gfsSM, NMM)



With nam soil moisture (NMM)



With gfs soil moisture (NMM)

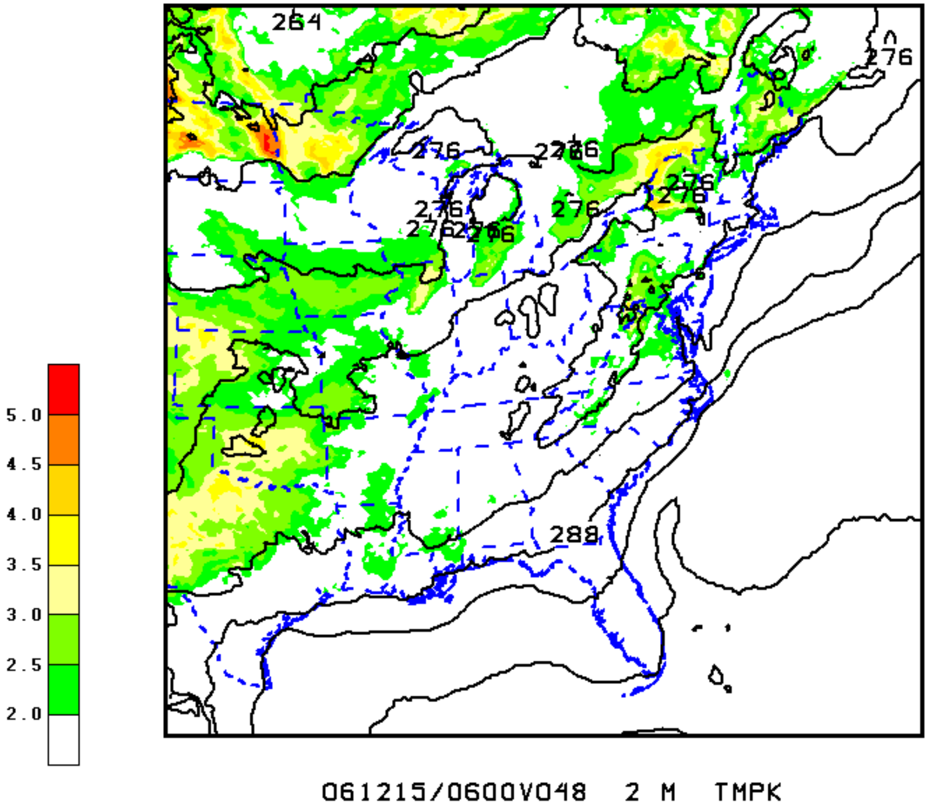
Met Ensembles for ATD
HREF 12 km Experiment

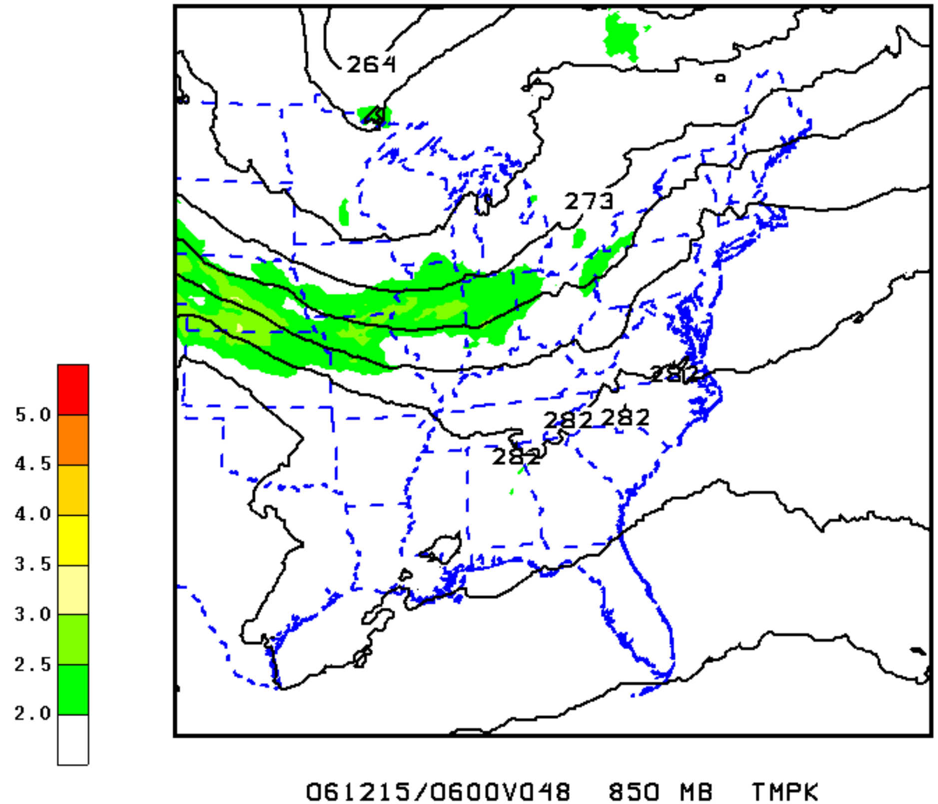
- **10 WRF members configured for Eastern U.S.**
  - *12 km DX, 48 hour forecasts, 2x/day (06 & 18 Z)*
  - *5 WRF ARW members (1 control, 2 breeding pairs)*
    - Physics: YSU PBL, Kain-Fritsch Convection, RRTM radiation
  - *5 WRF NMM members (1 control, 2 breeding pairs)*
    - Physics: MYJ TKE, Betts-Miller-J convection, GFDL radiation

- **Synoptic diversity: LBC & Breeding**
  - *Breeding: 12 hour forecast differences to drive IC perturbations*
  - *Lateral Boundary Conditions updated every 3 hours*
    - GENS 1-4 ET members for 2 NMM perturbed pairs
    - GENS 5-8 ET members for 2 ARW perturbed pairs
    - GENS Ctl for NMM and ARW control

Met Ensembles for ATD

HREF 12 km mean/spread



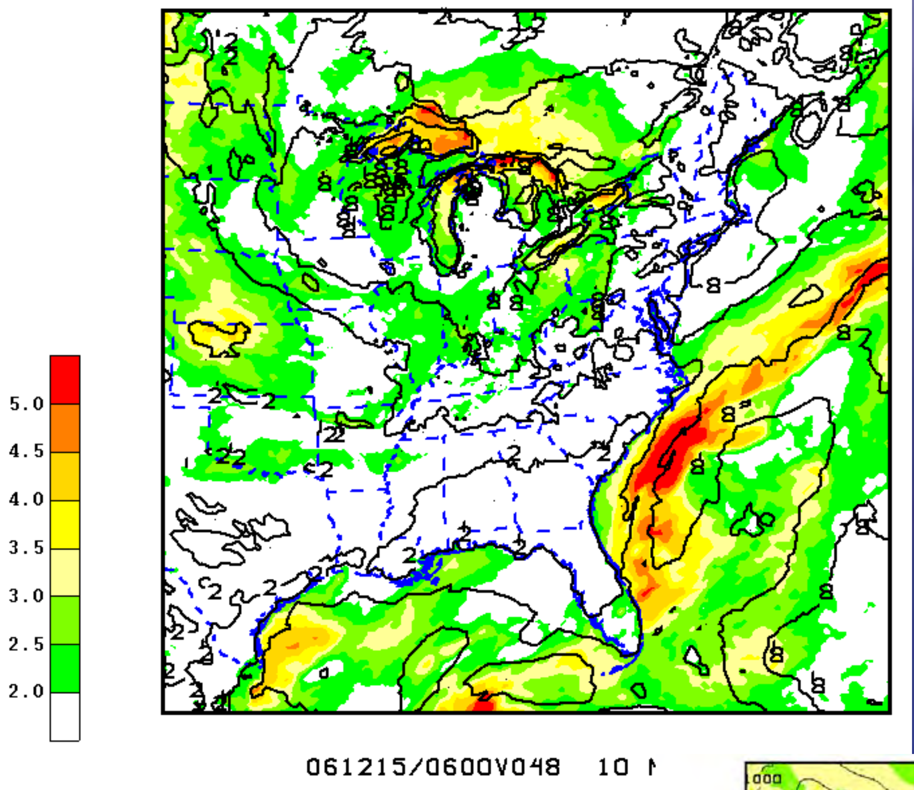


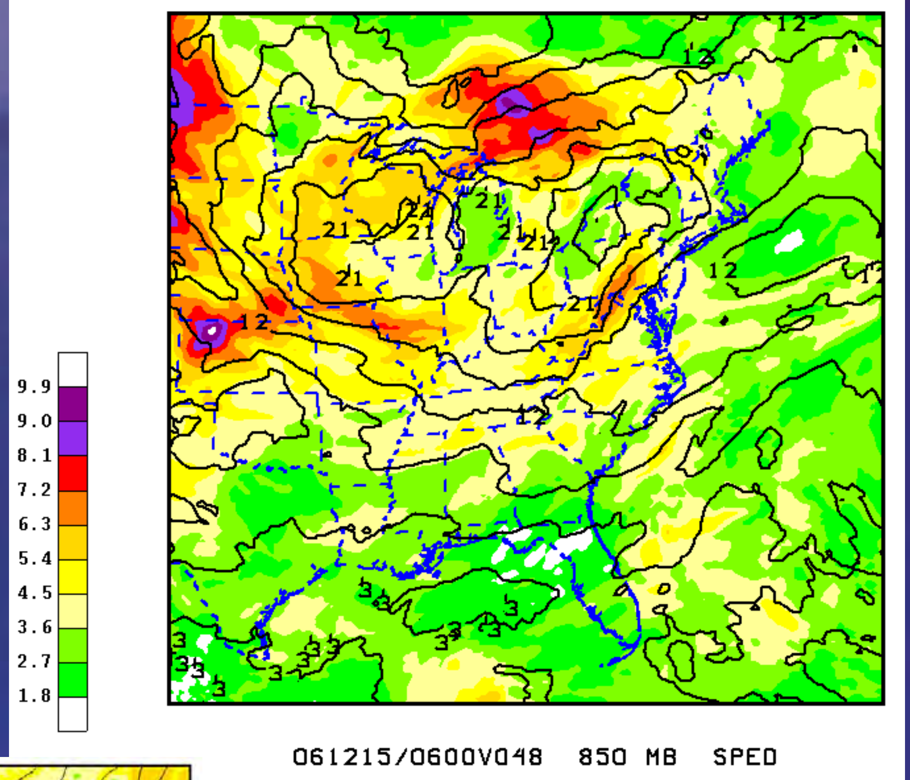
2 m Temperature mean/spread

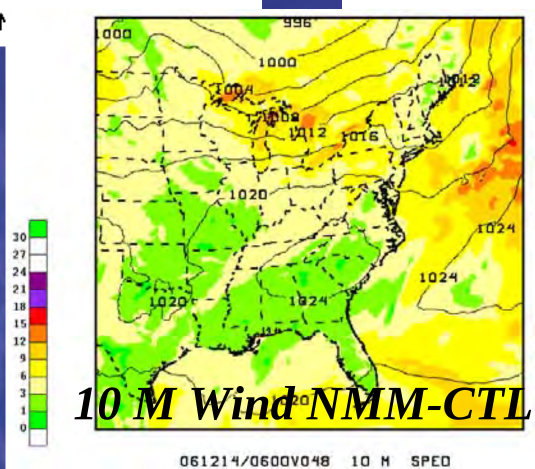
850 mb Temperature mean/spread

Met Ensembles for ATD

HREF 12 km mean/spread







10 M Wind NMM-CTL

10 m Winds

850 mb Winds

Future Work

- **Evaluate 12 km Relocatable HREF System**
  - ***Add pbl & LSM diversity to initial condition diversity system***
  - ***Compare against SREF, GENS, ARPS 4 km for NCEP/SPC spring program***

- **High Resolution Testing**
  - ***Test the addition of a 4 km nest to HREF NMM control***
  - ***Evaluate with DCNET and URBANET data***

- **Provision of Products**
  - ***Provision of ensemble median, wind variance and length scales to MDS for SCIPUFF sensitivity testing***

- **Complete evaluation of WRF turbulence & PBL fields for coupling with HPAC w/ PSU, Titan and Hanna Consultants**

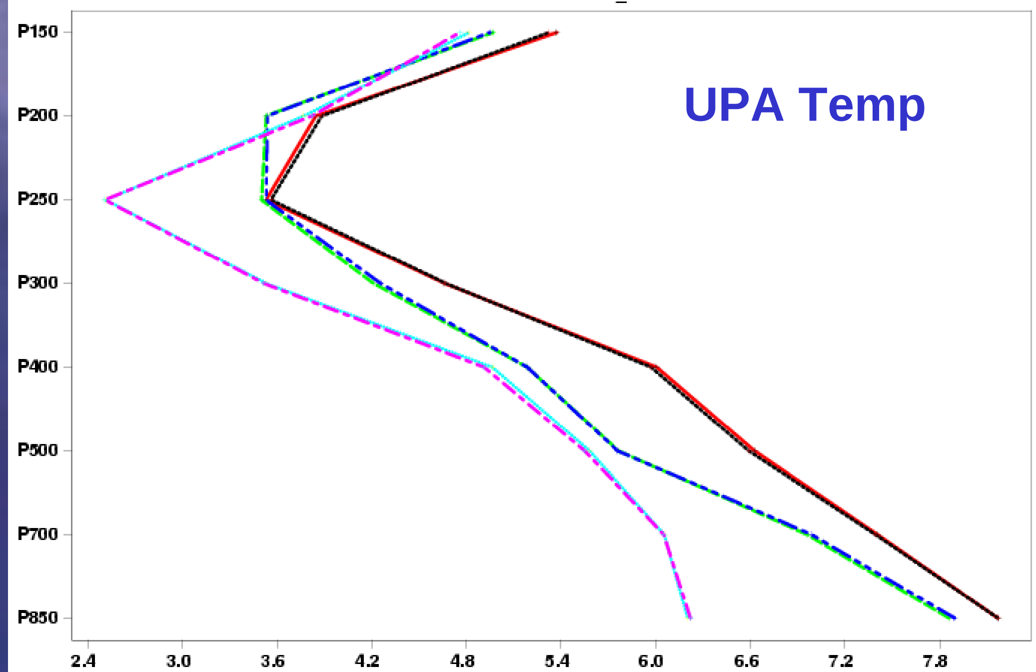
- **Improved probabilistic verification package**

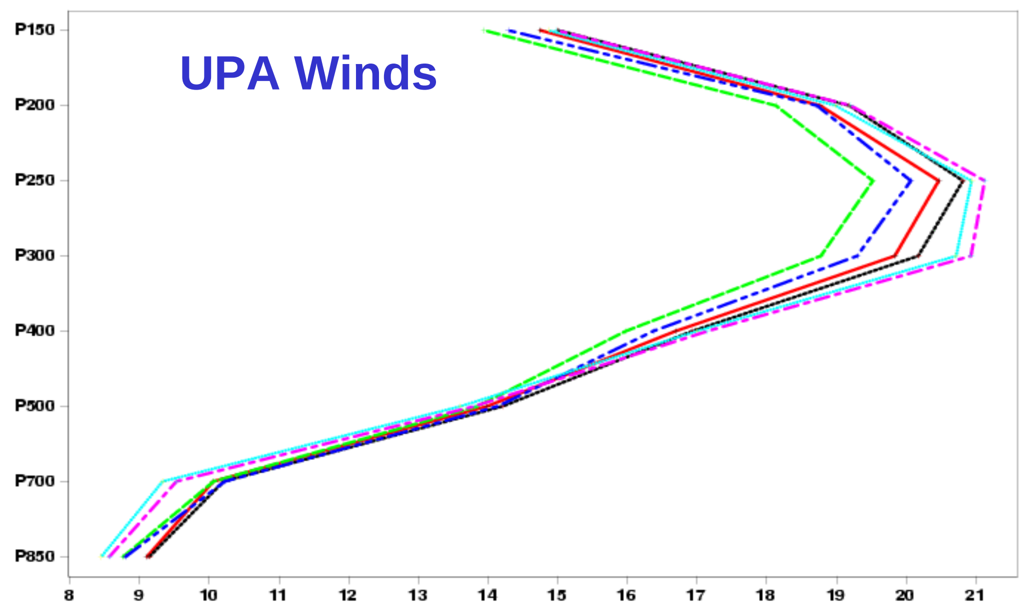
BACKUPS

SREF Performance

48 h forecast Spread (Nov. 2005)

CONUS
CONUS-21
EAST-15
EAST-21
West-15
West-21





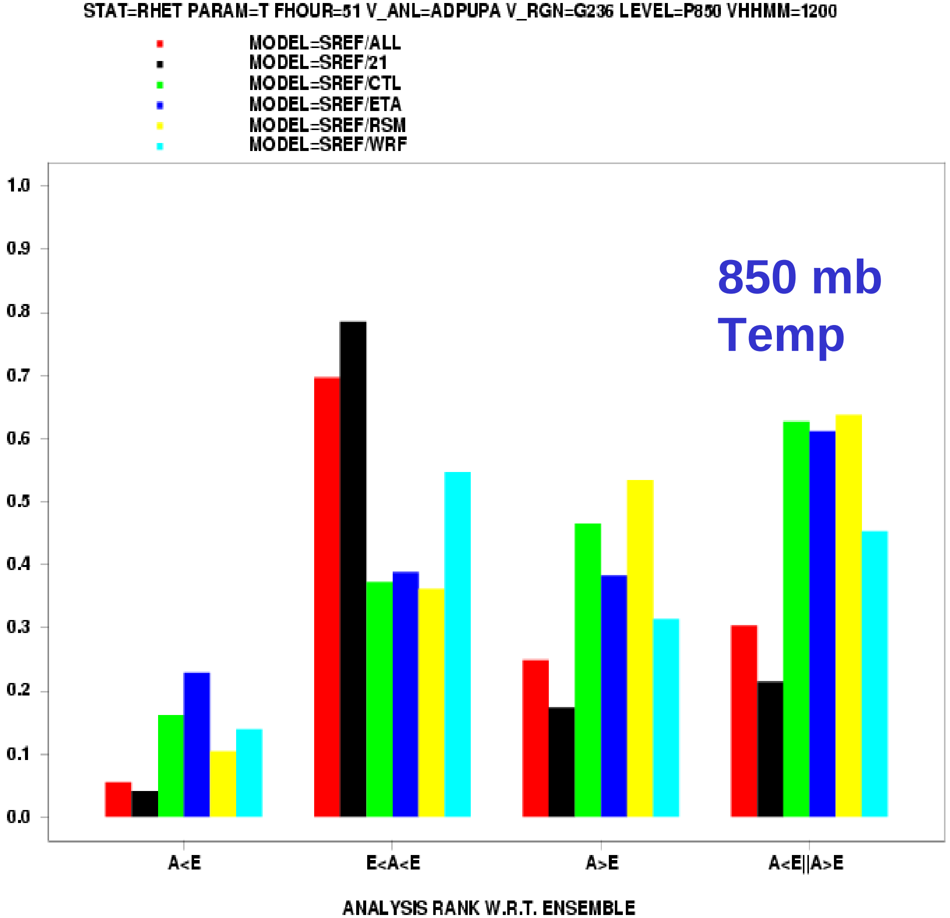
- *SREF-21 improved over SREF-15*

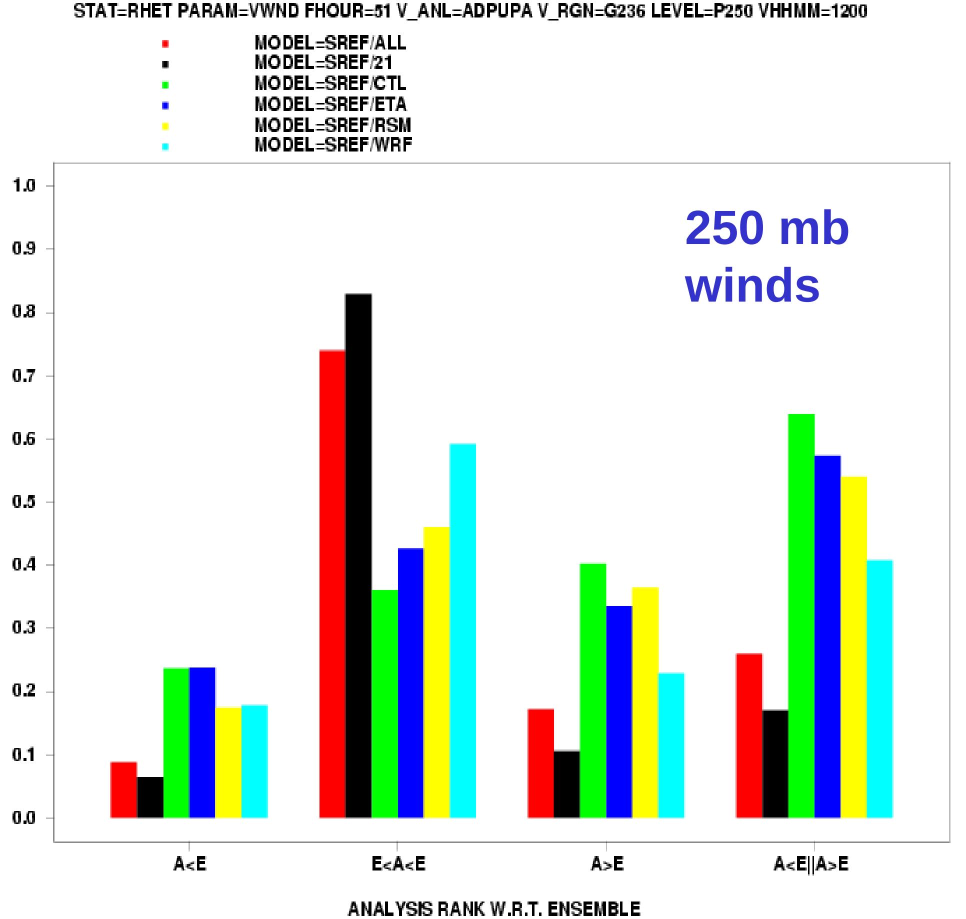
- ***Temperature:***
  - ***Spread is smallest in West and near Tropopause***
- ***Winds:***
  - ***Spread is greatest in West and near Tropopause***

SREF Operational Performance

Outlier Percentage

48 h forecasts (November 2005)

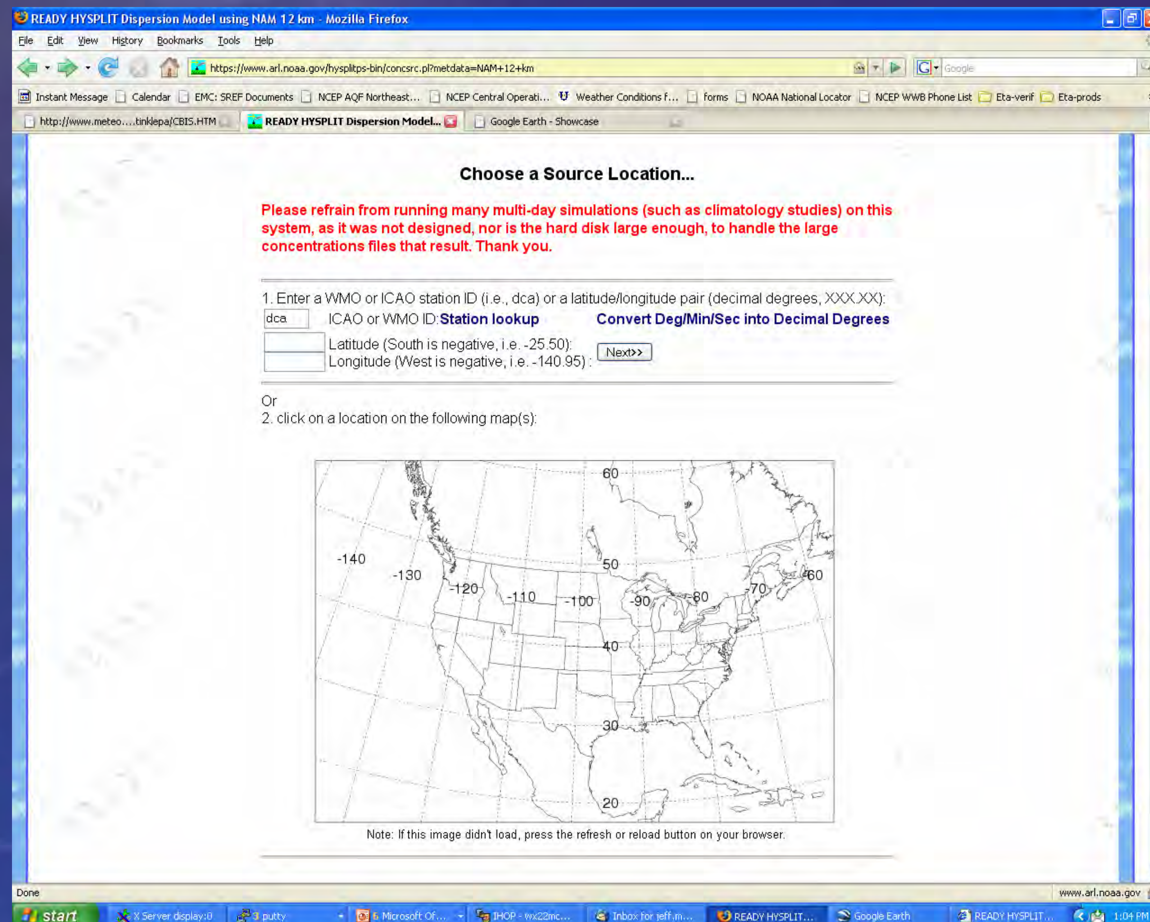




- *Outlier percentage reduced for SREF/21 system*
- *WRF sub-member agree best w/ obs as compared to Eta and RSM sub-members*

ARL HYSPLIT Web Interface

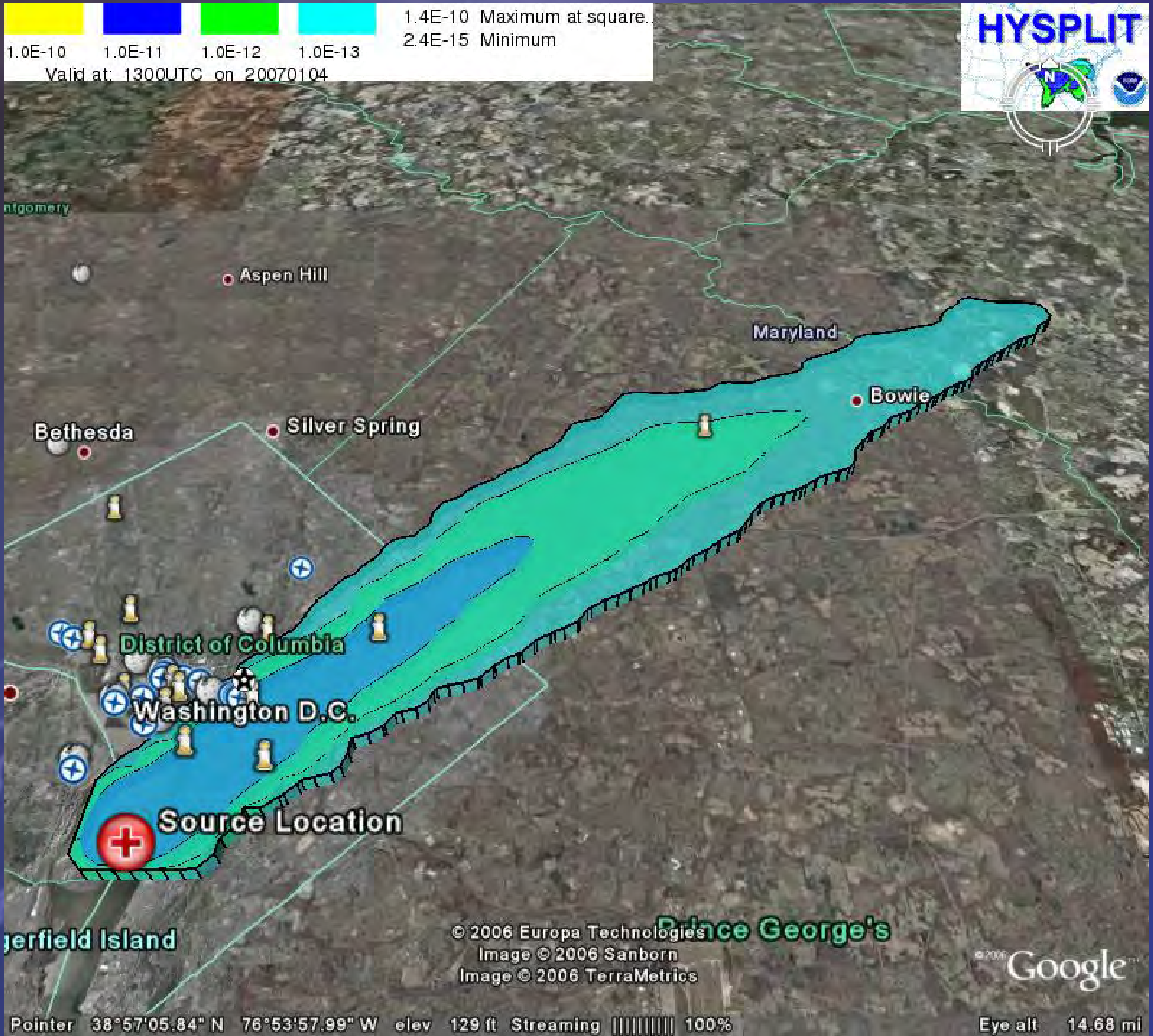
- Web based interface that allow user to customize:



- Source location
- Source strength
- Deposition effects
- Release Duration
- Forecast Length
- Graphical Display
  - ESRI GIS
  - Google Earth Interface

ARL HYSPLIT Web Interface

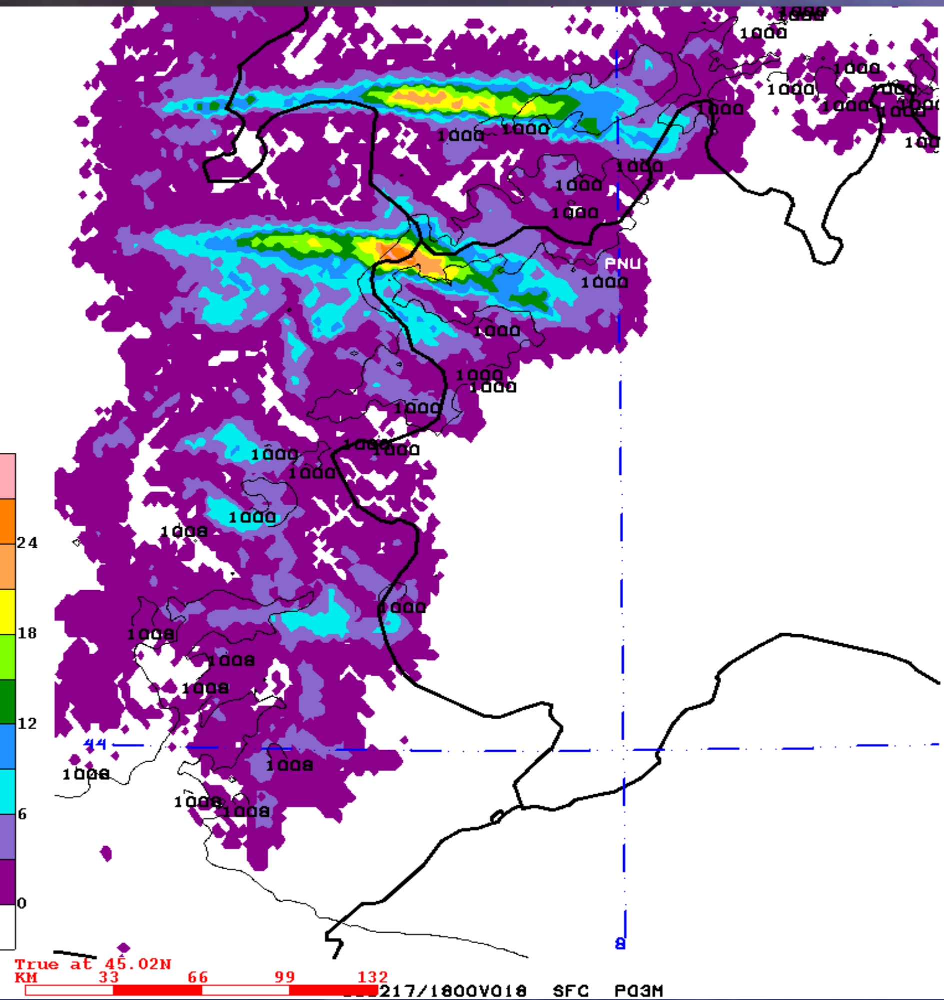
Google Earth Display

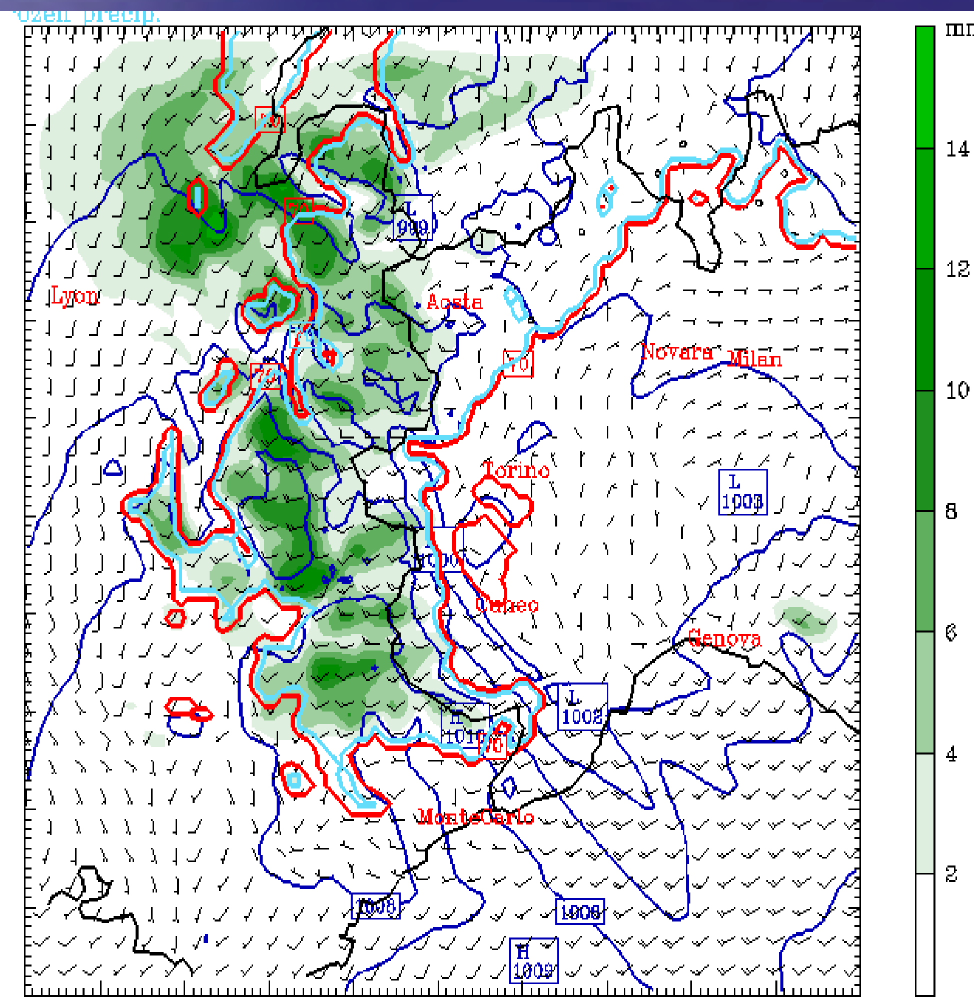


Torino Olympics

Snow Storm Forecasts (3h prcip)

00 UTC Feb. 17, 2006 18 h Forecasts

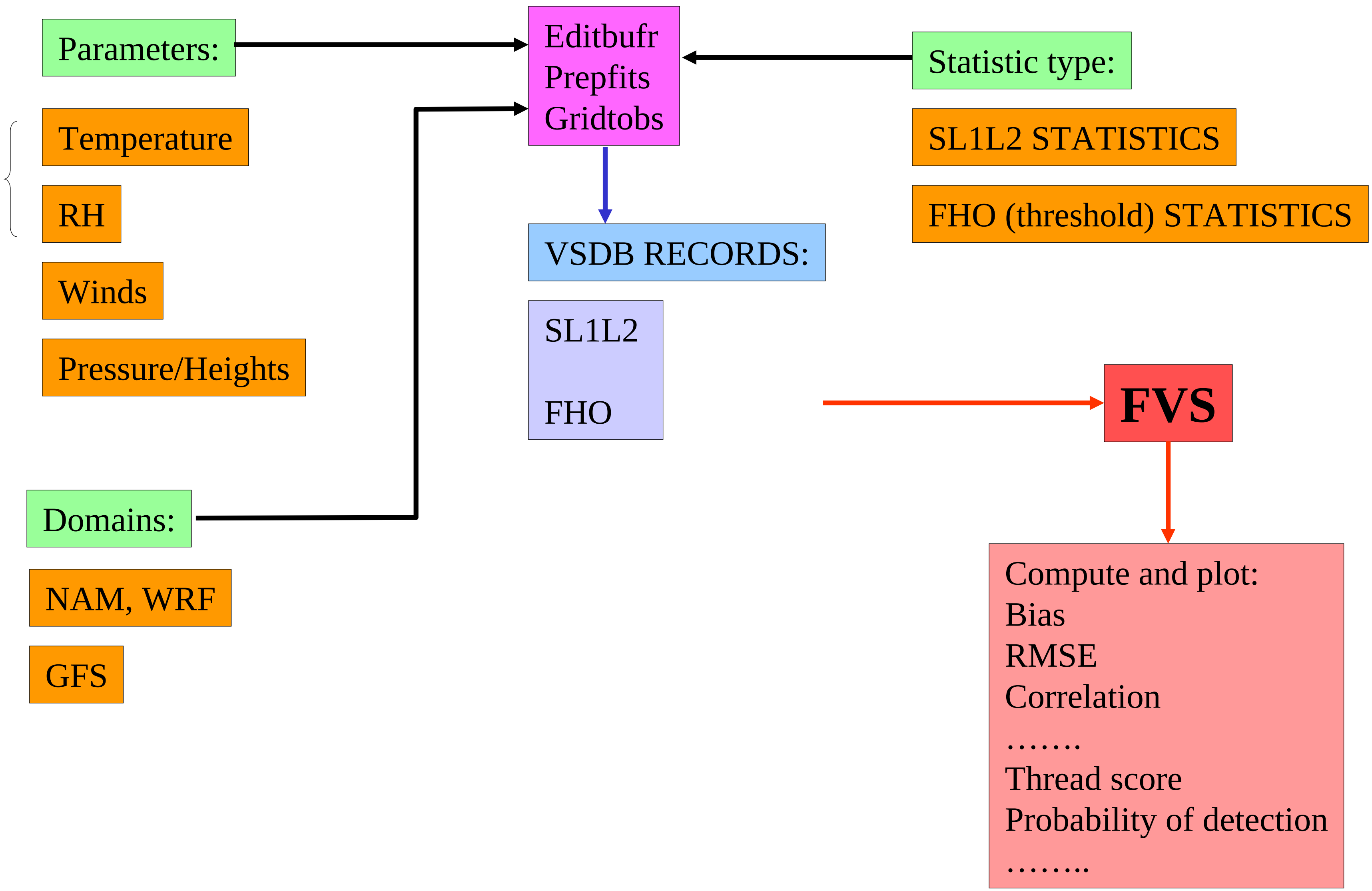


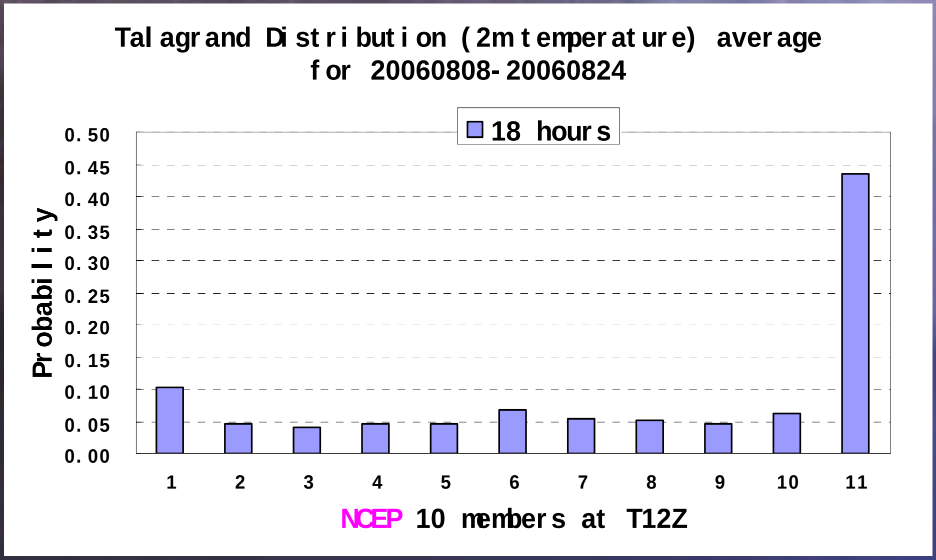


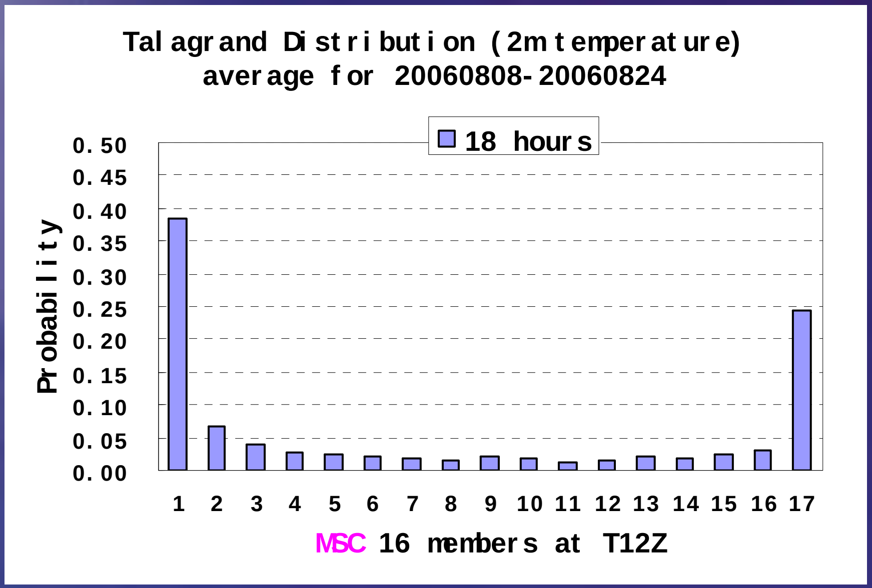
WRF-NMM 4km Zoom

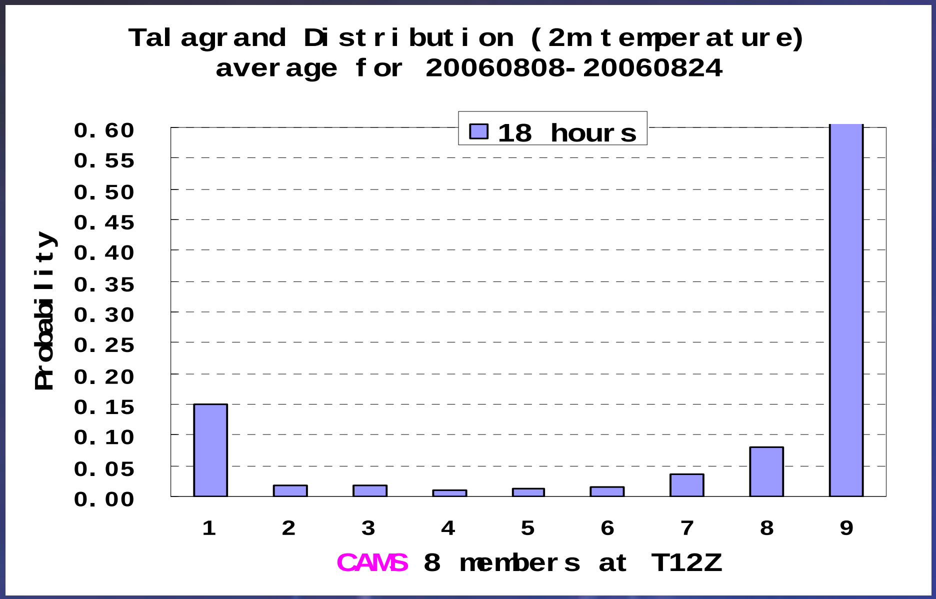
MM5 4 km

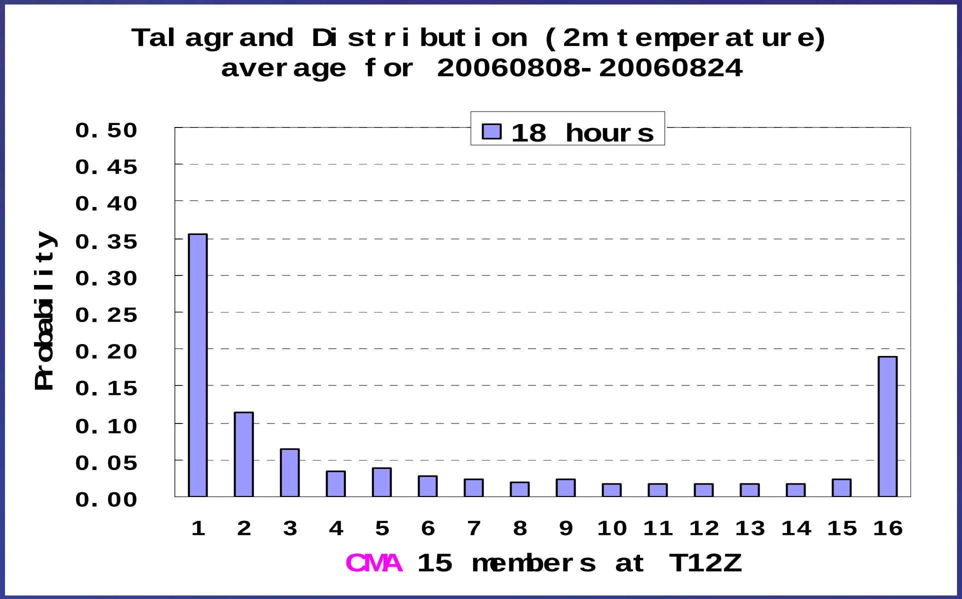
FVS VERIFICATION







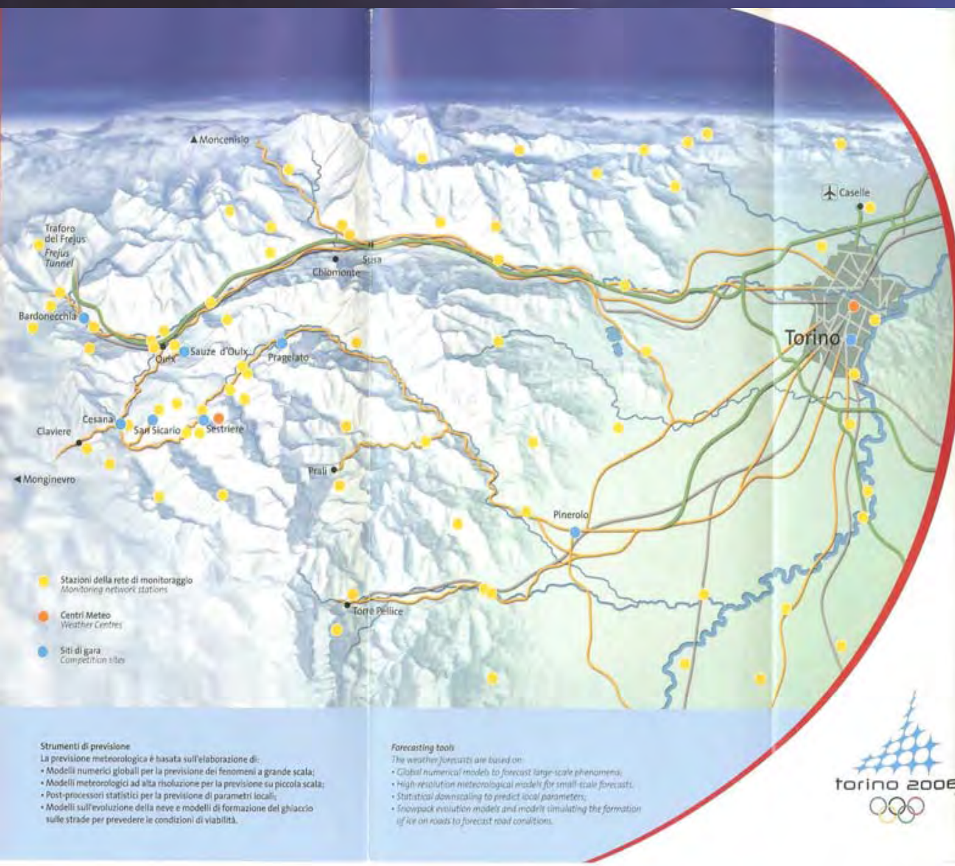


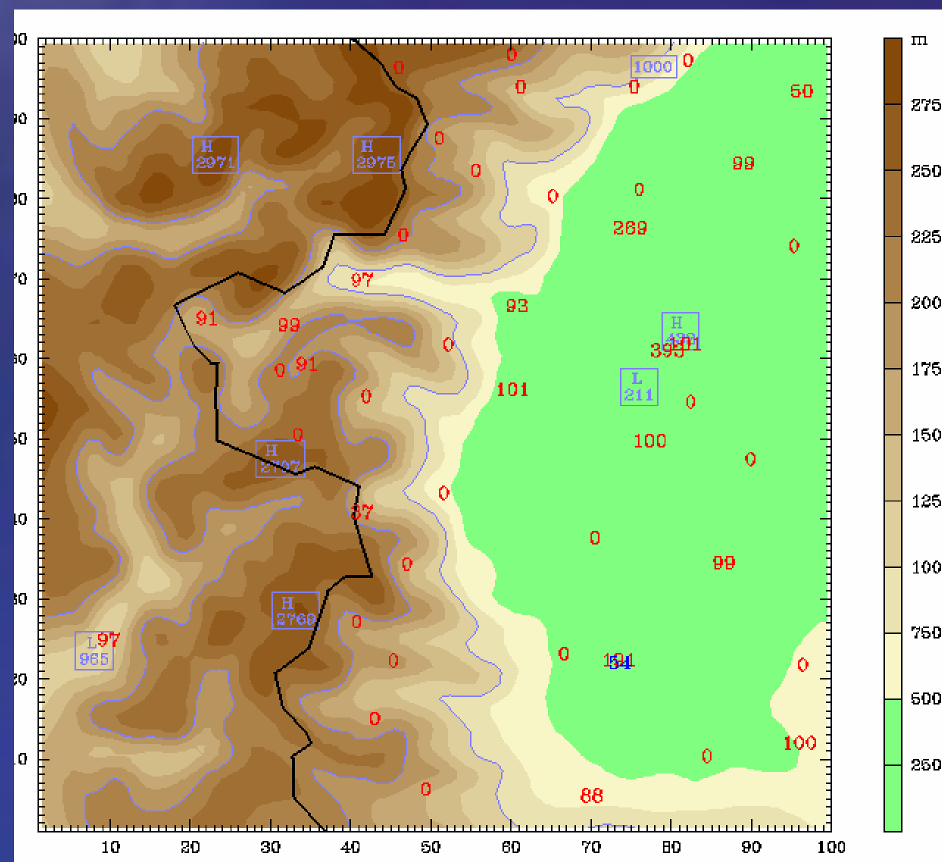


(from NMC/CMA, Y. Li)

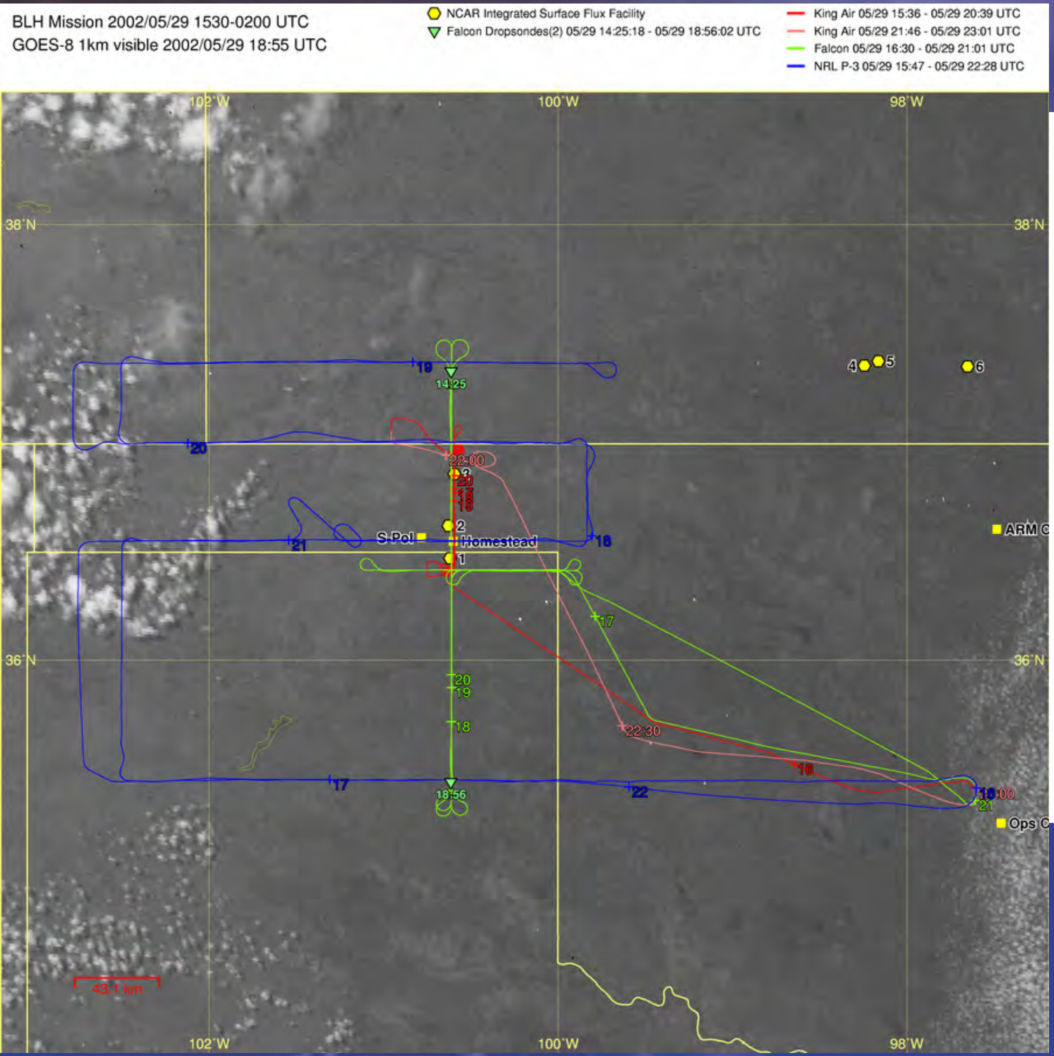
Torino Olympics

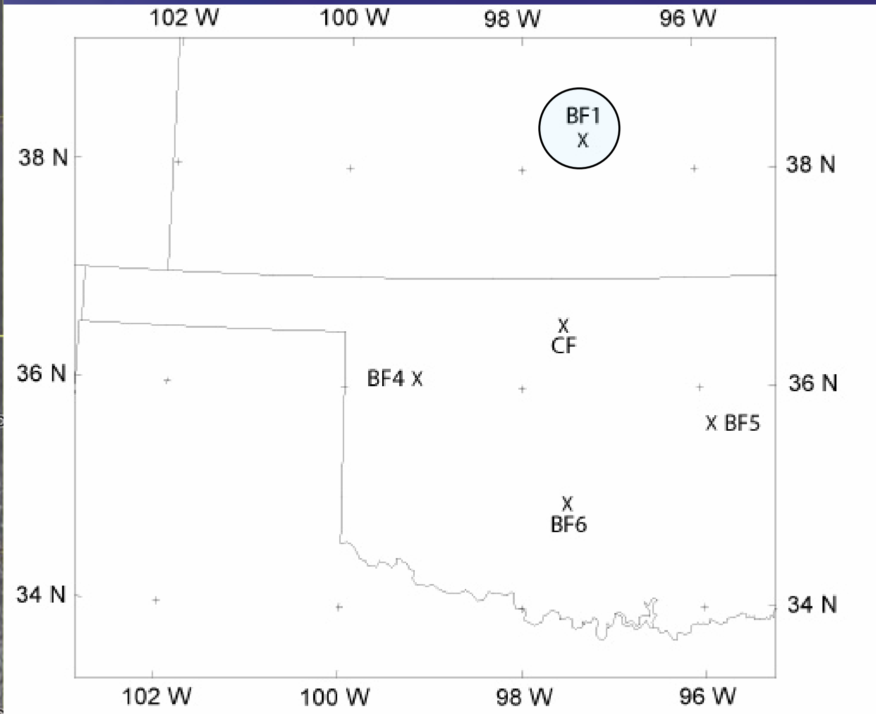
Venues and Mesonet Locations (D. Stauffer)



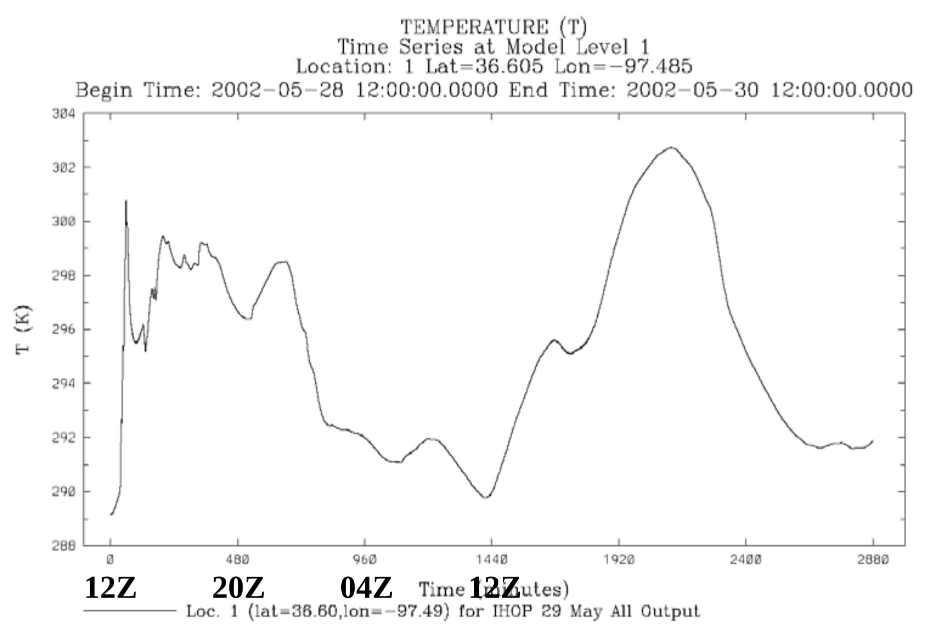


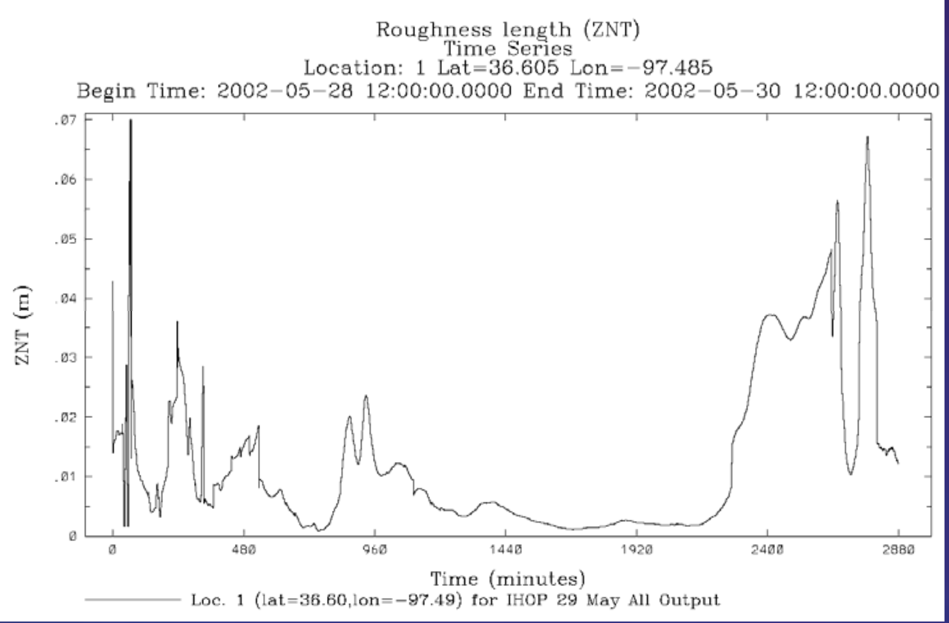
IHOP May 29, 2002 case

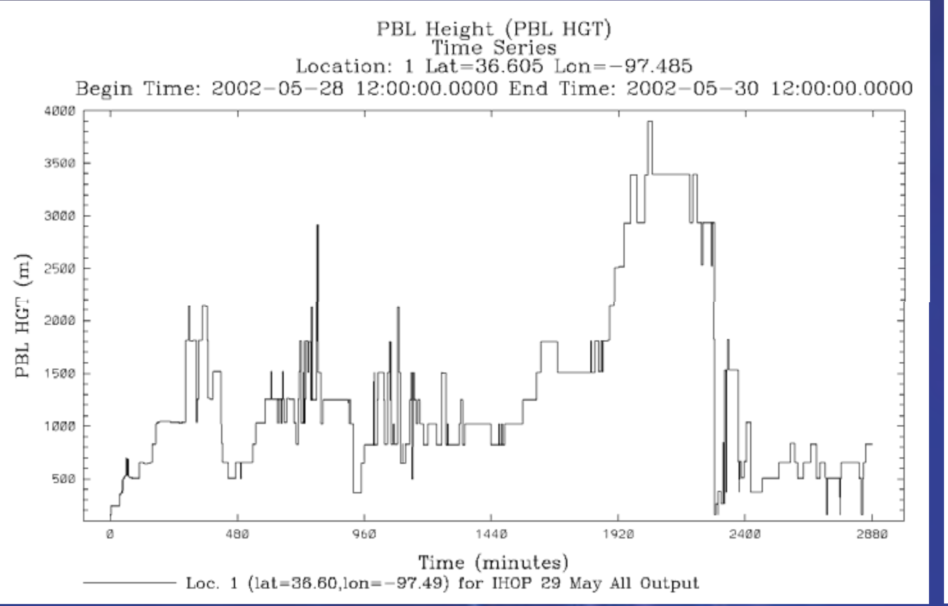


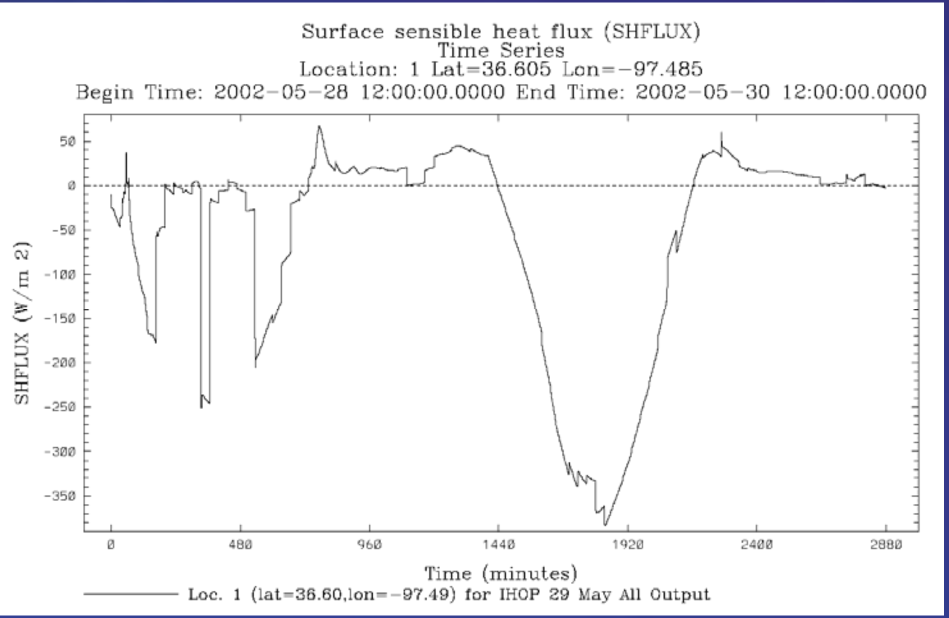


IHOP May 29, 2002 case

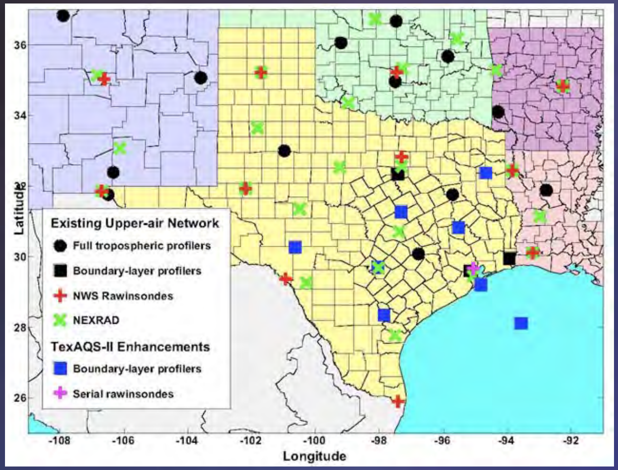








Two field campaigns provide intensive observations for potential use in regional analysis

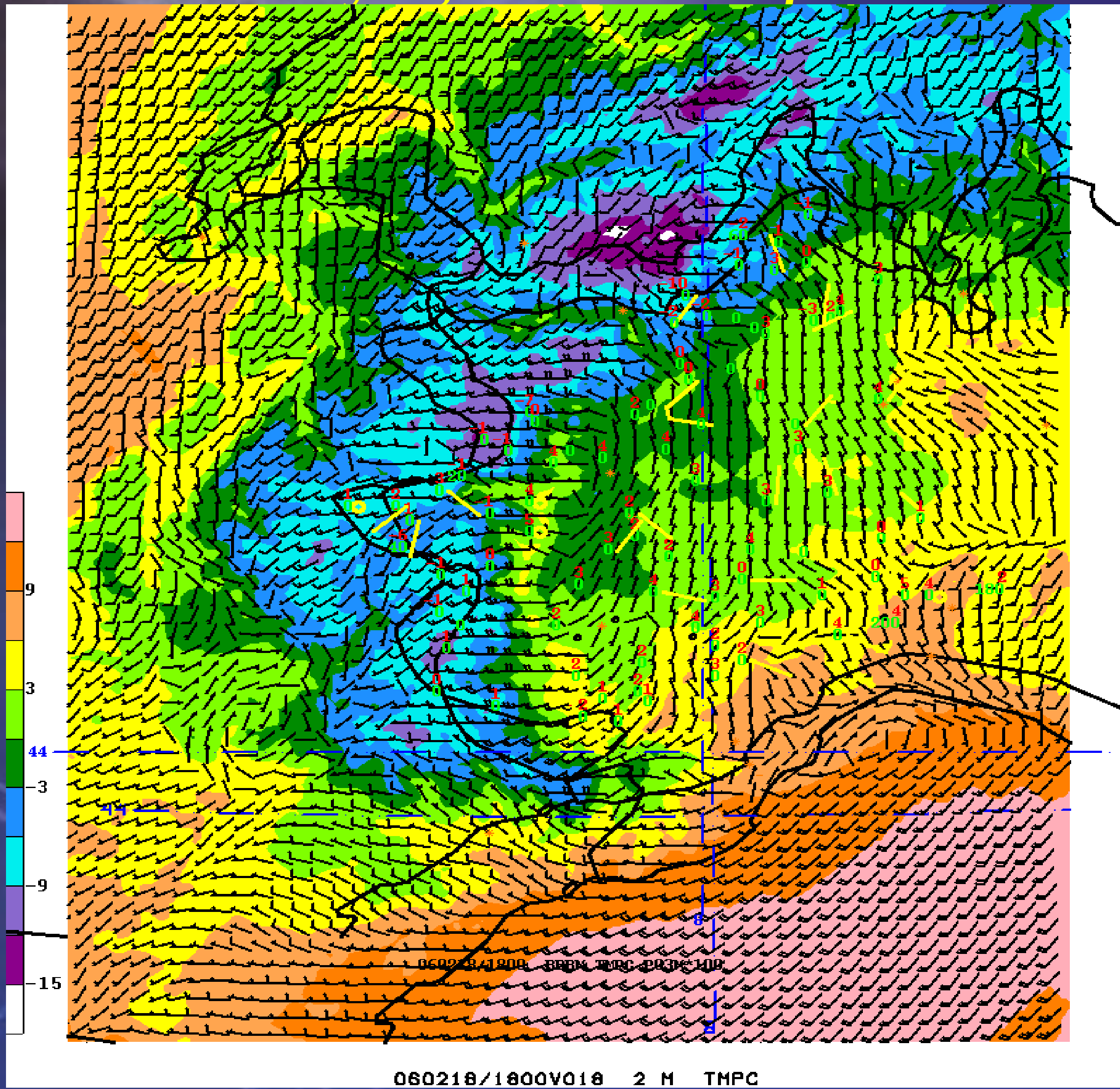


2006 Texas Air Quality Study/Gulf of Mexico Atmospheric Composition and Climate Study (8/1 - 9/30)

WAVES_2006: Water Vapor Validation Experiment – Satellite/Sondes in Beltsville, MD (7/17– 8/10)

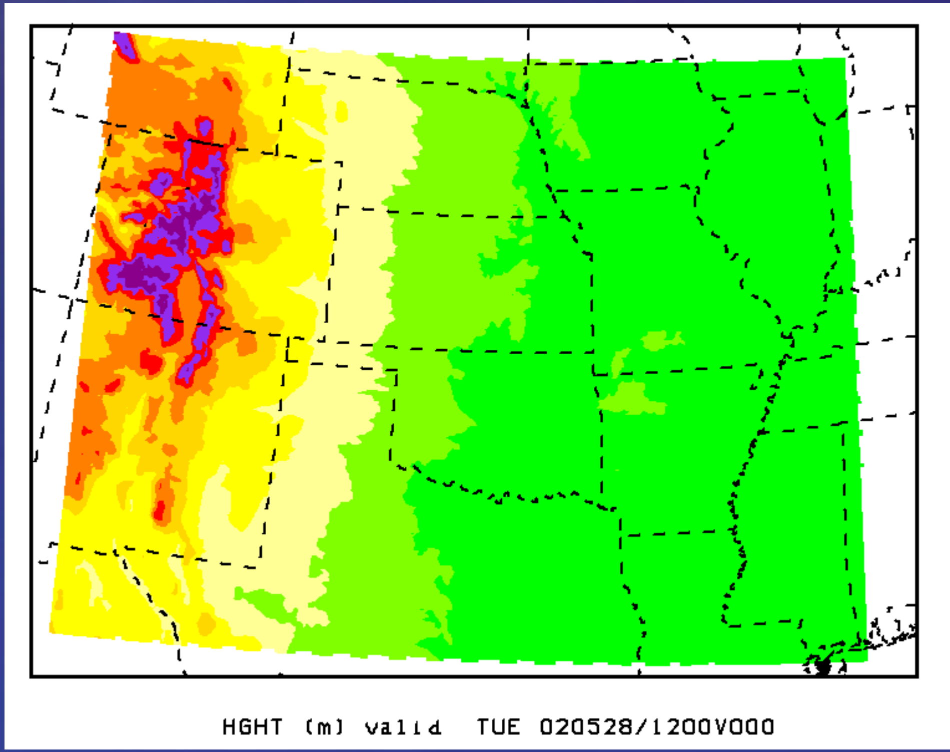
Torino Olympics

February 18, 2006 case temperature

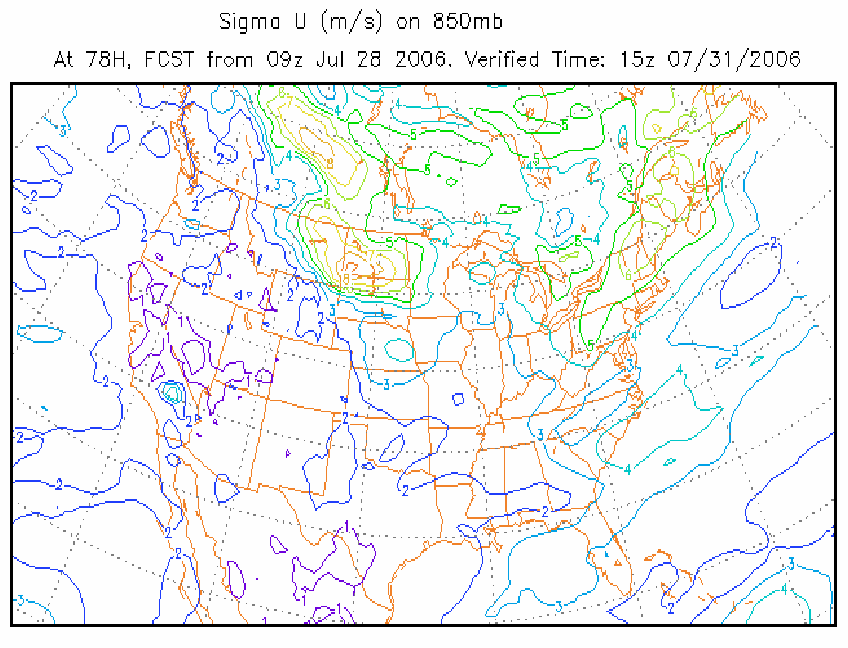


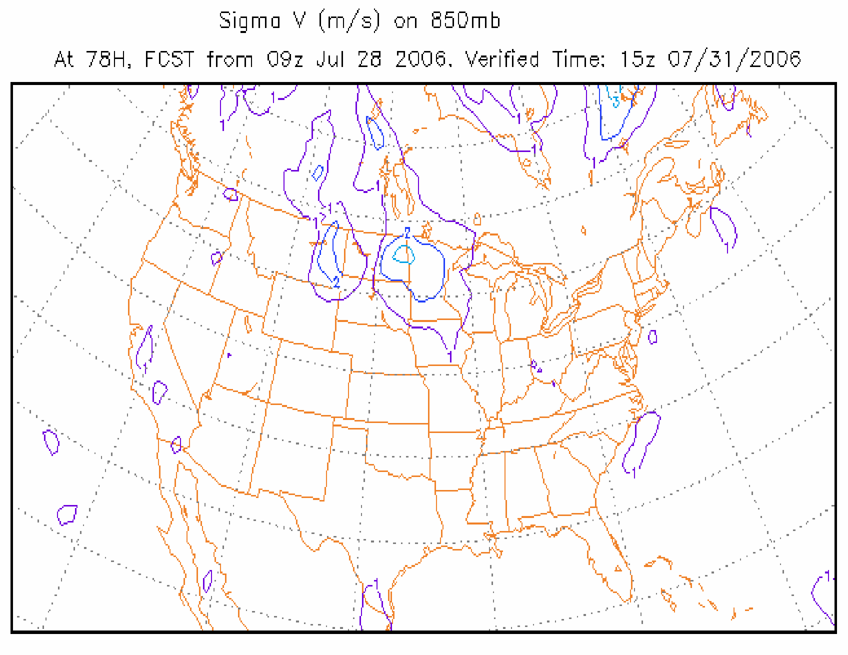
IHOP May 29, 2002 case

- **WRF-NMM Initialized from NDAS at May 28, 2002, 12Z**
- **4 km, 50 Level, 48 hour forecasts**
- **Central U.S. Nest (260x410)**
- **Mellor-Yamada-Janjic TKE**
- **NOAH LSM**
- **Ferrier Micro-physics**
- **Betts-Miller-J Convection**

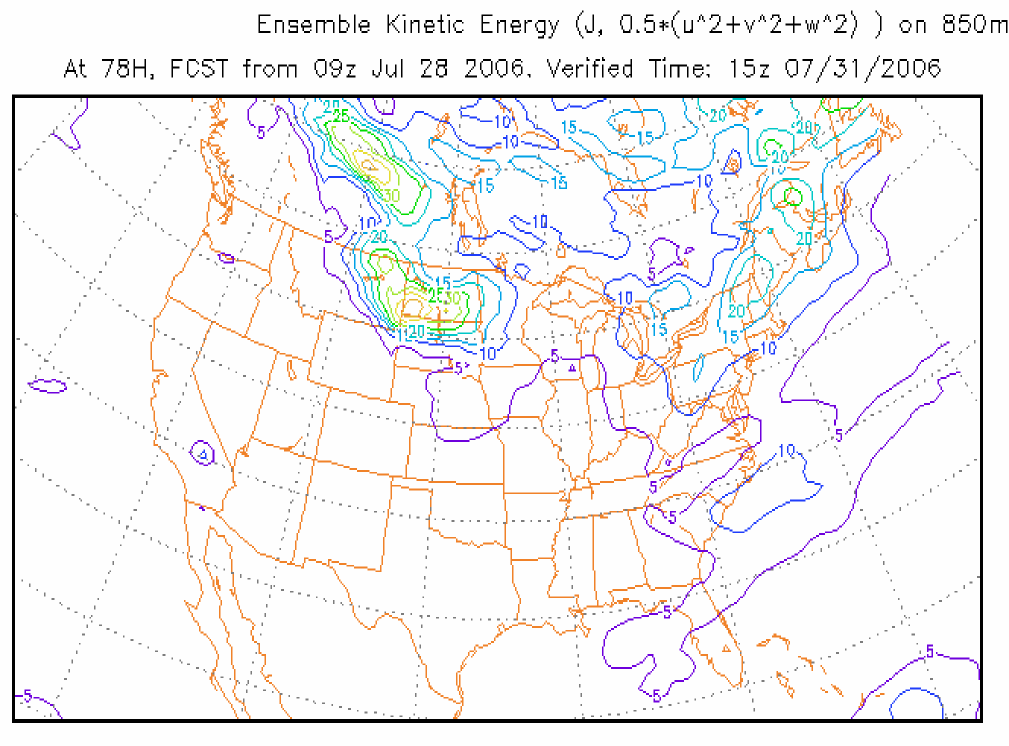


Ensemble Covariance Products





Binbin Zhou, EMC

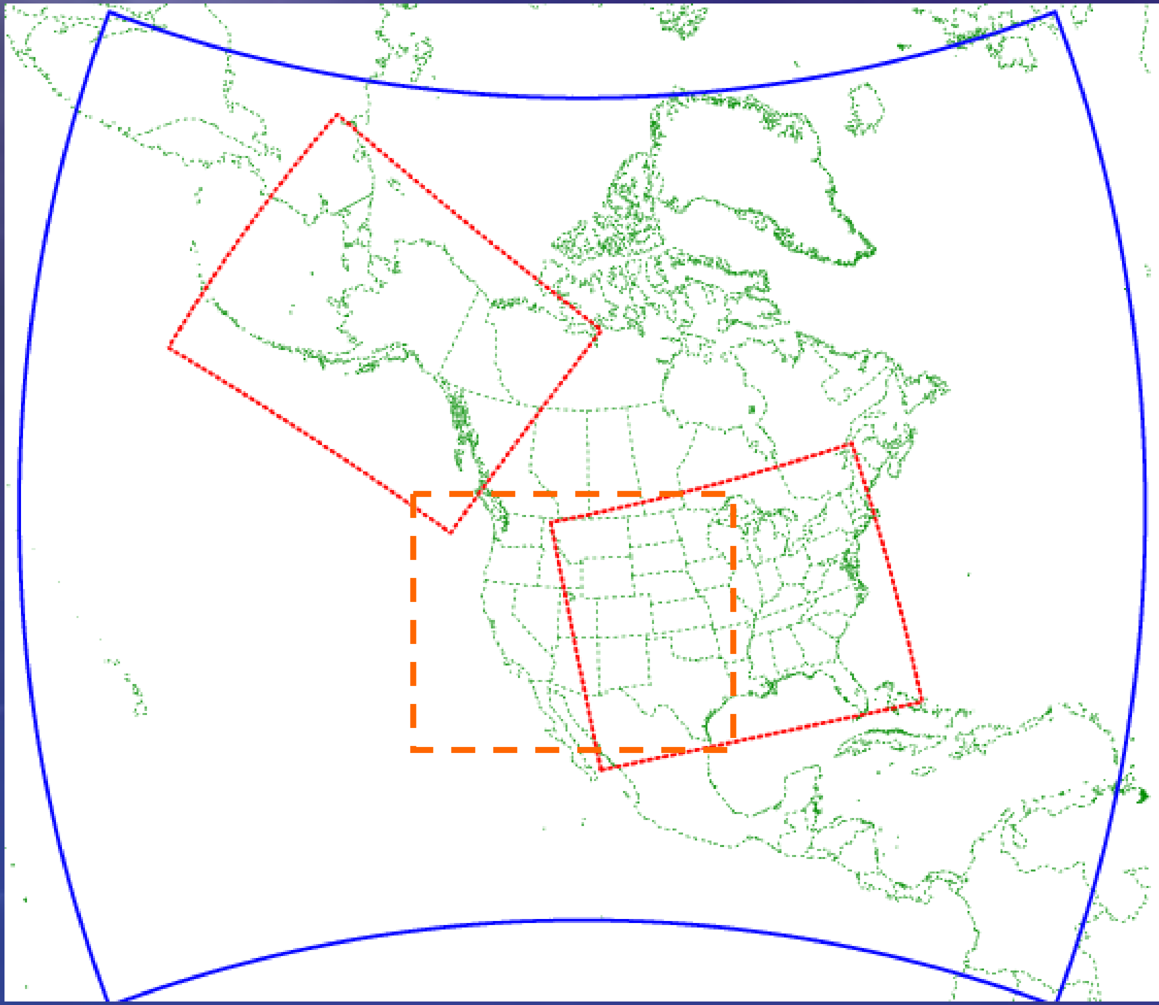


EKE=0.5*(UU+VV+WW), where UU, VV, WW are ensemble variances

HiResWindow Fixed-Domain Nested Runs

Proposed ~4km run Configuration

- **FOUR routine runs made at the same time every day**
- **00Z : ECentral & Hawaii**
- **06Z : Alaska & Puerto Rico**
- **12Z : ECentral & Hawaii**
- **18Z : WCentral & Puerto Rico**
- **Everyone gets daily high resolution runs *if & only if* hurricane runs are not needed**



http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/

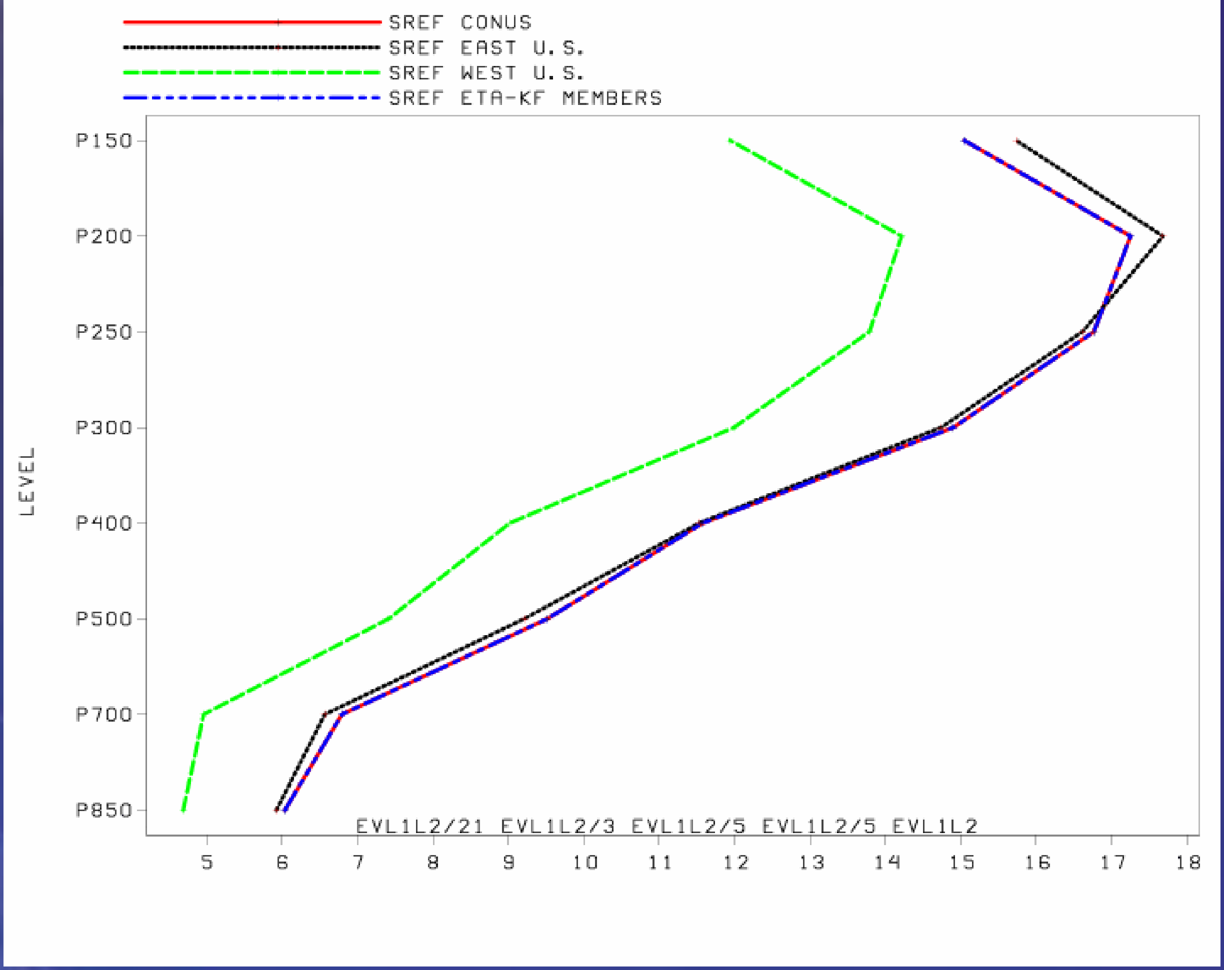
SREF Performance

48 h Wind forecast Spread (August 2006)

CONUS

EAST-21

West-21



- *Spread is largest in East and near Tropopause*

Sensor Location Optimization Tool Set (SLOTS)

Chemical Biological Information Systems (CBIS) Conference

11 January 2007

Michael J. Smith, Javad Sedehi, Scott Mitchell,

Mark Henning, Samuel Freund, Stuart Edick,

Julie Tittler

Engineered for life

Overview

- SLOTS Objective
- Technical Approach
- Automating Rules-based Placement
- Genetic Algorithm Optimization
- Test Case Runs
- Summary

Sensor Location Optimization Tools Set (SLOTS) Program Objective

Automate **the rules-based process and** ***optimize*** **the location of sensors to detect, identify, and quantify the CB hazard in support of the commander's intent.**

Sensor Location and Optimization Tool Set (SLOTS)

Technical Approach

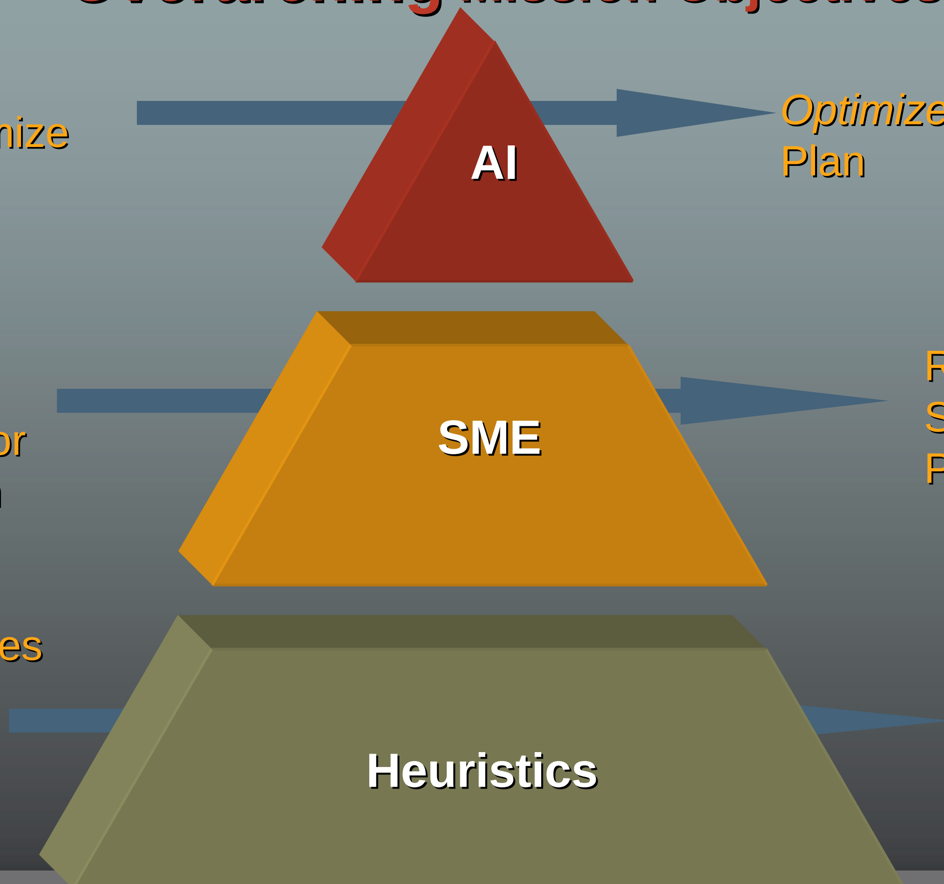
Overarching Mission Objectives

Approach:

3. Leverage artificial intelligence to optimize the ultimate sensor configuration.

2. Utilize information technologies to automate the sensor placement decision process.

1. Establish a set of rules governing the emplacement of sensors.



Outcomes:

Optimized Sensor Placement Plan

Rules-based Sensor Placement Plan

Handbook of Doctrine, TTP, Rules of Thumb and (available) OIF Lessons Learned

The SLOTS Architecture

Automated Rules-based Placement

•Provide a graphical representation to visualize the operational implications of sensor placement heuristics. Provide a benchmark placement solution against which the Genetic Algorithm solution can be compared.

Simulation Cache

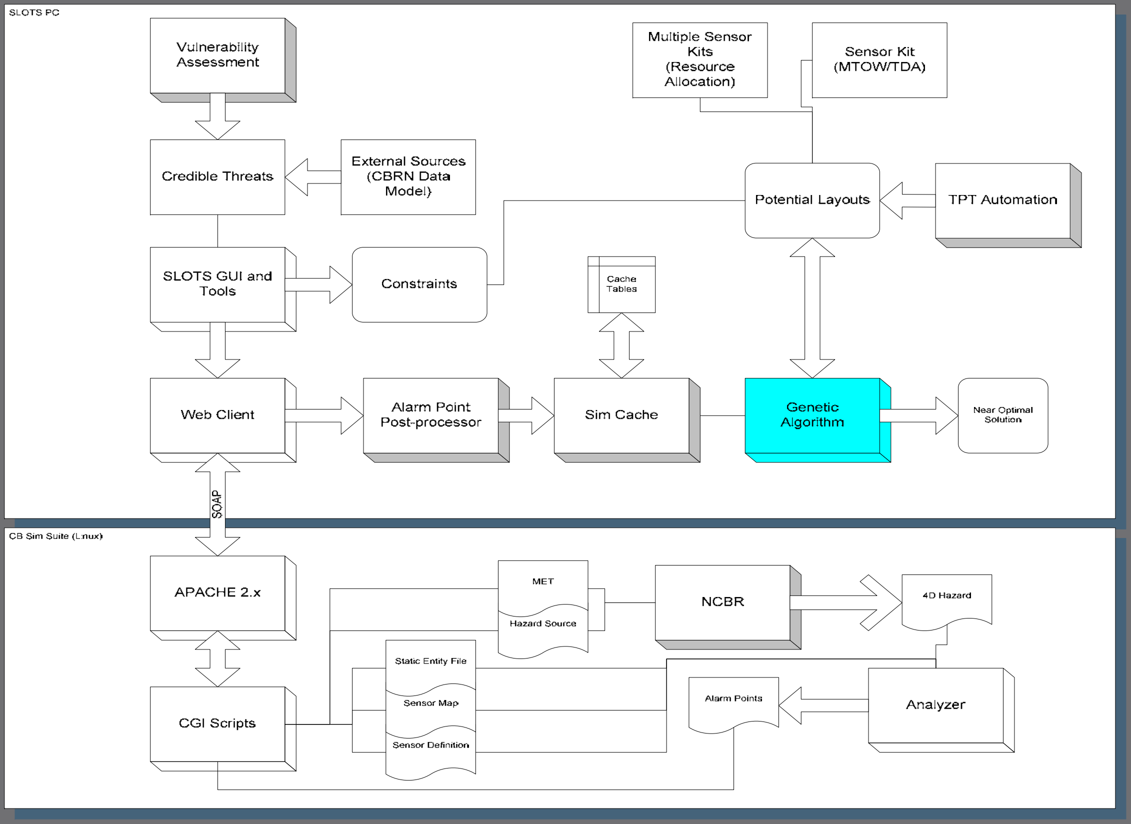
•Provide a means to employ physics based modeling and simulation to generate sensor placement environment and mitigate impact to operational timelines

Web Services Interface

•Provide an interchangeable interface to modeling and simulation tools, allowing user selectable hazard modeling applications (e.g. NCBR, JEM, etc.)

Genetic Algorithm

•Provide a global optimization solution for sensor placement.



Sensor Location Optimization Tools Set (SLOTS)
Handbook

Placement **Task: Supervise Positioning of the Chemical-Agent Alarm**
Number: 031-503-1020

1. Plan the positioning of the chemical-agent alarm. Consider the following:
a. Determine the wind direction and speed from a current CDM or by referring to GTA 3-2-2 for a
field expedient method.
b. Determine how far upwind to place the detectors. This distance is based on the following:
(1) The wind speed. The faster the wind speed, the farther upwind the detector should
be placed, not to exceed 150 meters.
(2) The weather. Rain or snow tend to wash the agent out of the air. Hot, sunny weather
will tend to create higher vapor concentrations.
(3) The terrain. The more broken the terrain and the more obstacles (trees and
buildings), the closer the detectors should be placed.
(4) The threat situation.
c. Determine the detector array to be used by considering all of the concerns above, the number
of detectors available, and the position of the unit (Figure 185).

2. Brief the emplacement teams on the exact location of the alarm.

3. Supervise the positioning of the chemical agent alarm. Check the following:
a. Ensure that the detectors are emplaced the maximum possible distance from the unit not to
exceed 150 meters.
b. Ensure that the detectors are spaced no more than 300 meters apart.
c. Ensure that the detectors are not placed where obstructions could alter wind currents.
d. Ensure that the detectors are connected to alarms with telephone cable (WD/TT). Maximum
wiring distance should not exceed 400 meters.
NOTE: Up to five alarms may be connected to one detector.
e. Ensure that the alarms are placed near monitoring positions.
4. Determine the warning time. Warning times for different distances and wind speed can be
determined using the following formula: Warning Time (min) = (Distance (m) x 60 (min/hr)) / (Wind
Speed (kmph) x 1,000) Warning time (sec) = (Distance (m) x 36 (sec/hr)) / (Wind Speed (kmph) x 10)
*NOTE: The automatic chemical-agent alarm system can be used only to warn against chemical
agents drifting into the unit location. It provides no warning against on-target attacks.*
5. Ensure that the detectors are repositioned when the wind direction changes.

SLOTS Automated Rules-based Placement (ARP)

Dice Five Algorithm

- For each base,
  - The user must pick a center, *UAcenter*, or it is calculated as the centroid of the user-defined polygon representing the base outline.
  - The coordinates of each base are shifted such that *UAcenter* is at the origin, and rotated so that wind direction is parallel to the Y axis.
- Sensor positions of the Dice 5 layout are then defined by the functions:

$$CenterPoint = \left(i * SensorDistance,\ j * SensorDistance\right)$$

$$UpperLeftSquarePoint = \left(\frac{2i-1}{2} * SensorDistance, \frac{2j-1}{2} * SensorDistance\right)$$

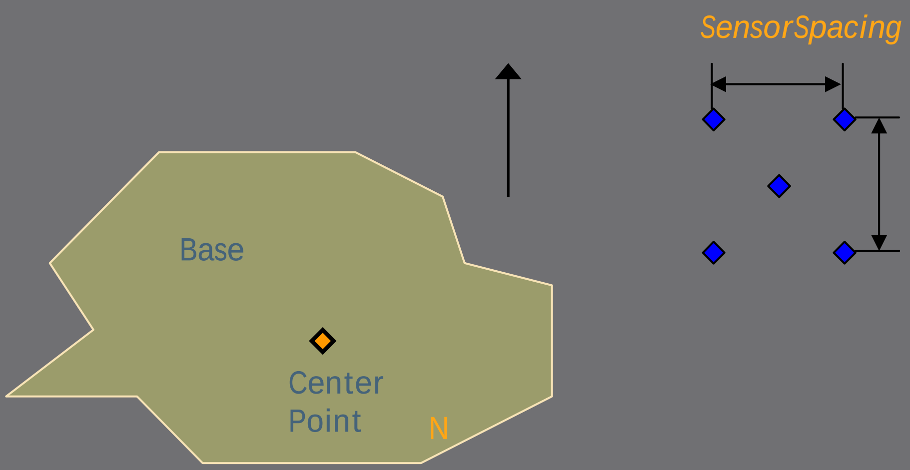
- where *i* and *j* are integers constrained by the size of the Base. The bounds of *i* and *j* are calculated by

$$floor\left(\frac{MaxW}{SensorDistance} - \frac{1}{2}\right) \le i \le ceiling\left(\frac{MaxE}{SensorDistance} + \frac{1}{2}\right)$$

- and

$$floor\left(\frac{MaxS}{SensorDistance} - \frac{1}{2}\right) \le j \le ceiling\left(\frac{MaxN}{SensorDistance} + \frac{1}{2}\right)$$

- where Max* are the maximum extents of the base (relative to *UAcenter*) in each cardinal direction.



•The set of points must be checked against the actual bounds of the base. Sensor Positions outside this area must be discarded.

•If not enough sensors are available for a complete Dice 5 pattern, sensors are placed around the perimeter first, sorted secondarily by how far they are upwind (furthest toward MaxN, after rotation).

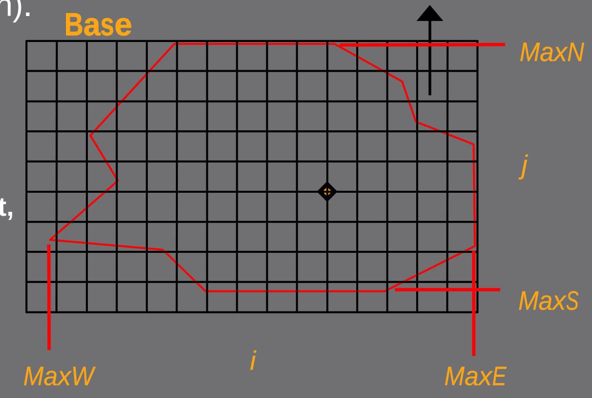


Figure 3 – Centerpoint, rotated grid

SLOTS Automated Rules-based Placement
Picket Fence Placement Algorithm

Find Central Front-most manned position

1. select $\overline{M_i}$ with the minimum distance from intersection of ideal x & max($\overline{y_i}$)

Place Sensor

1. Sensor$_i$ is the intersection of

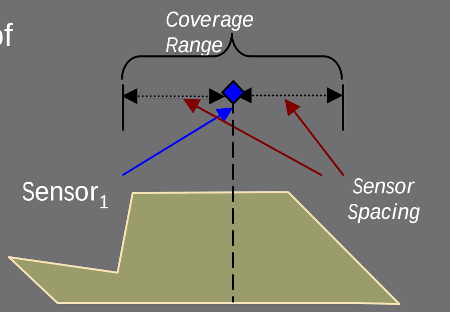
a. Circle $\left(x-\overline{M_{ix}}\right)^2+\left(y-\overline{M_{iy}}\right)^2 = SensorDistance^2$

b. The *SensorLine*… ≈ Centerline +/- n**SensorDistance*

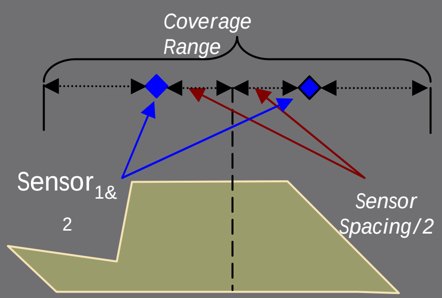
c. $y=\overline{M_{iy}} \pm \sqrt{SensorDistance^2-\left(SensorLine-\overline{M_{ix}}\right)^2}$

- This can result in 0, 1, or 2 points.
  - For 0 (i.e. *y* is imaginary), recalculate a, b, and c using the sensor's maximum physical distance in place of *SensorDistance*. If there are still 0 points, place *Sensor$_i$* at the maximum plus the sensor's maximum $\overline{M_{iy}}$ physical distance at *SensorLine*.
  - For 1, choose that point.
  - For 2 pick the upwind point.

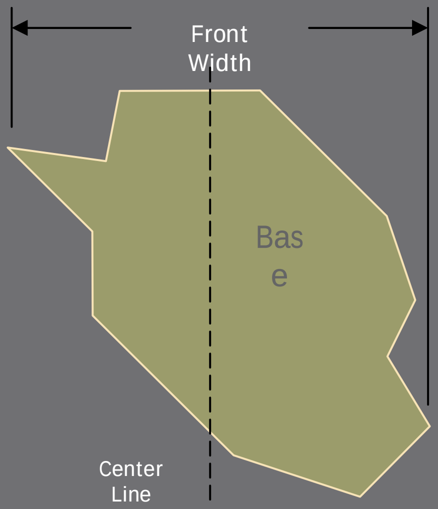
e. Repeat a through d for each $\overline{M_i}$ within *SensorDistance* (or physical distance) and pick the point furthest upwind, letting *SensorDistance* placements always have priority over physical distance placements.



Odd Sensor starting placement

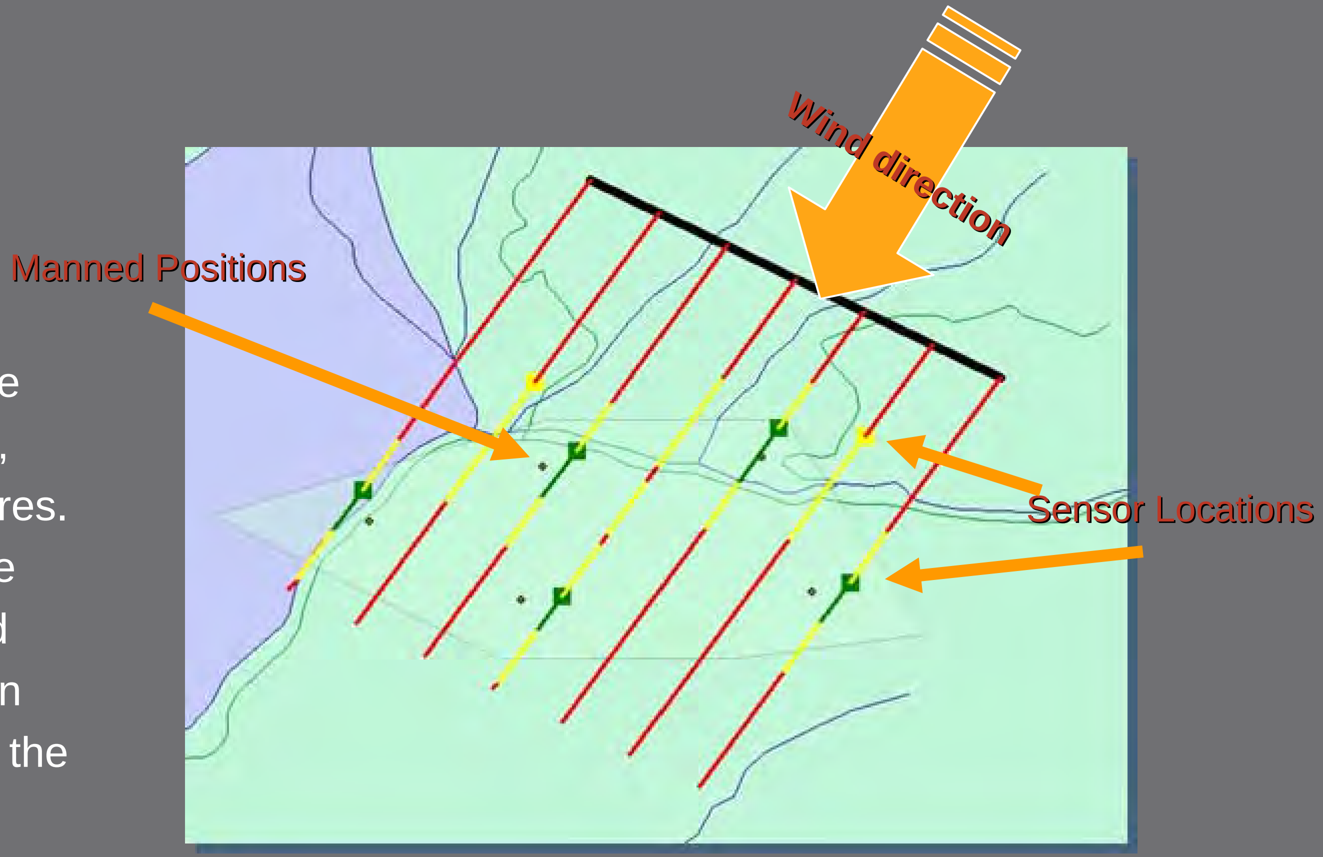


Even sensor starting placement



SLOTS Automated Rules-based Placement (ARP)

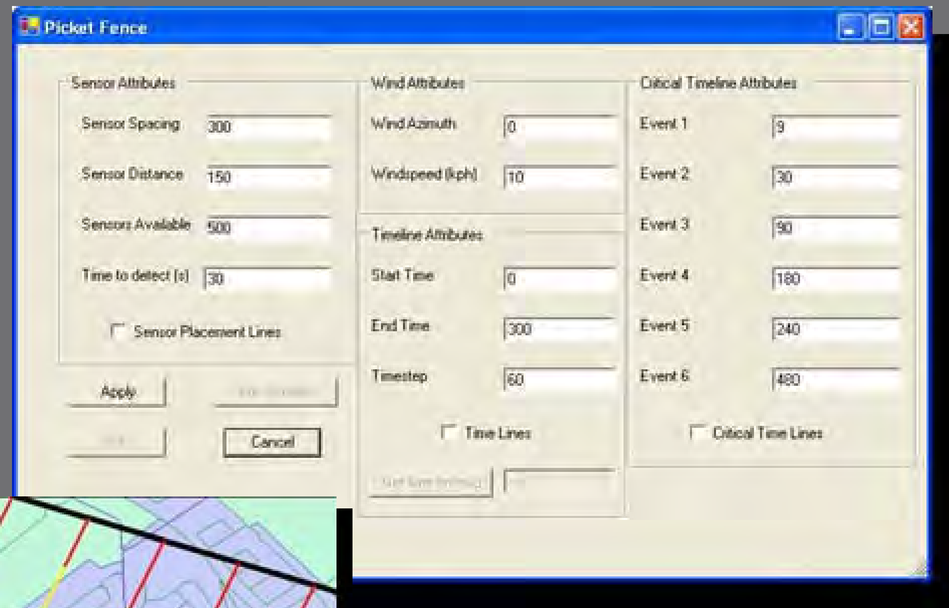
The ARP provides visualization of sensor positions and compliance with doctrine and tactics, techniques and procedures. Also suggests alternative positions and associated risk. It provides decision maker with quick look at the "goodness" of given a sensor placement scheme.

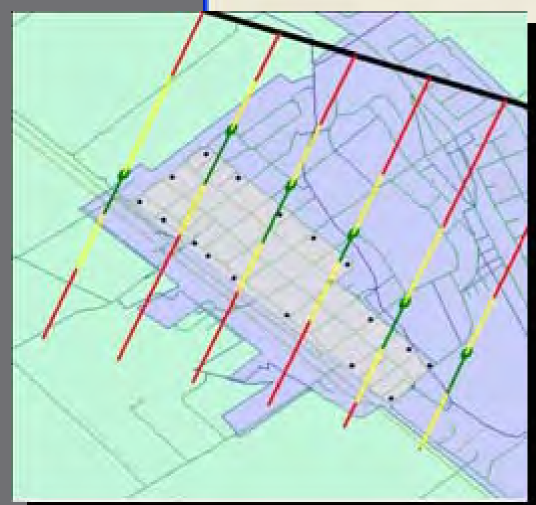


Picket Fence

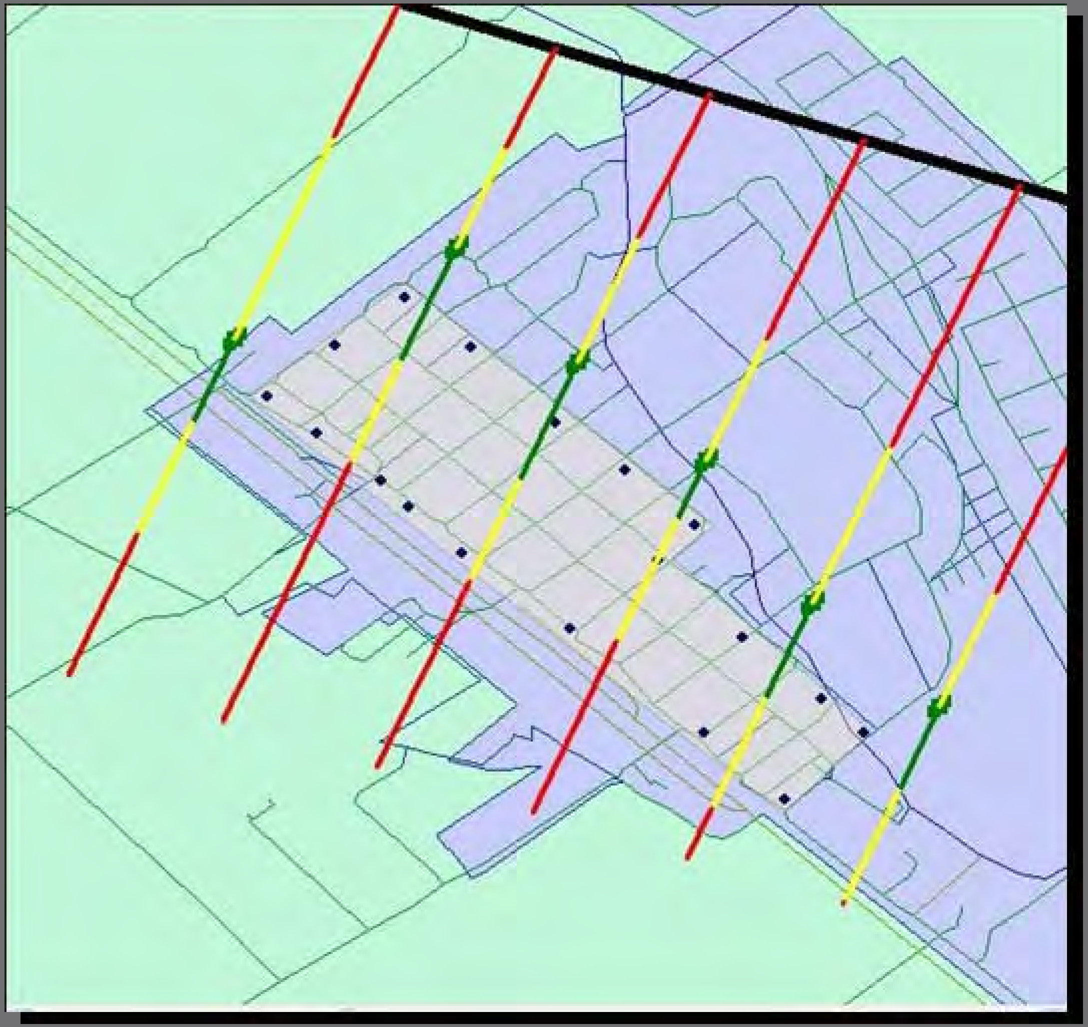
- Sensors evenly spaced along border
- Upwind of base to yield longer warning times

- Automated Implementation
- Rule Violations –Green, Yellow, & Red
- Two Implementations - Sensors placed from:
  - Fixed locations
  - Movable locations within base

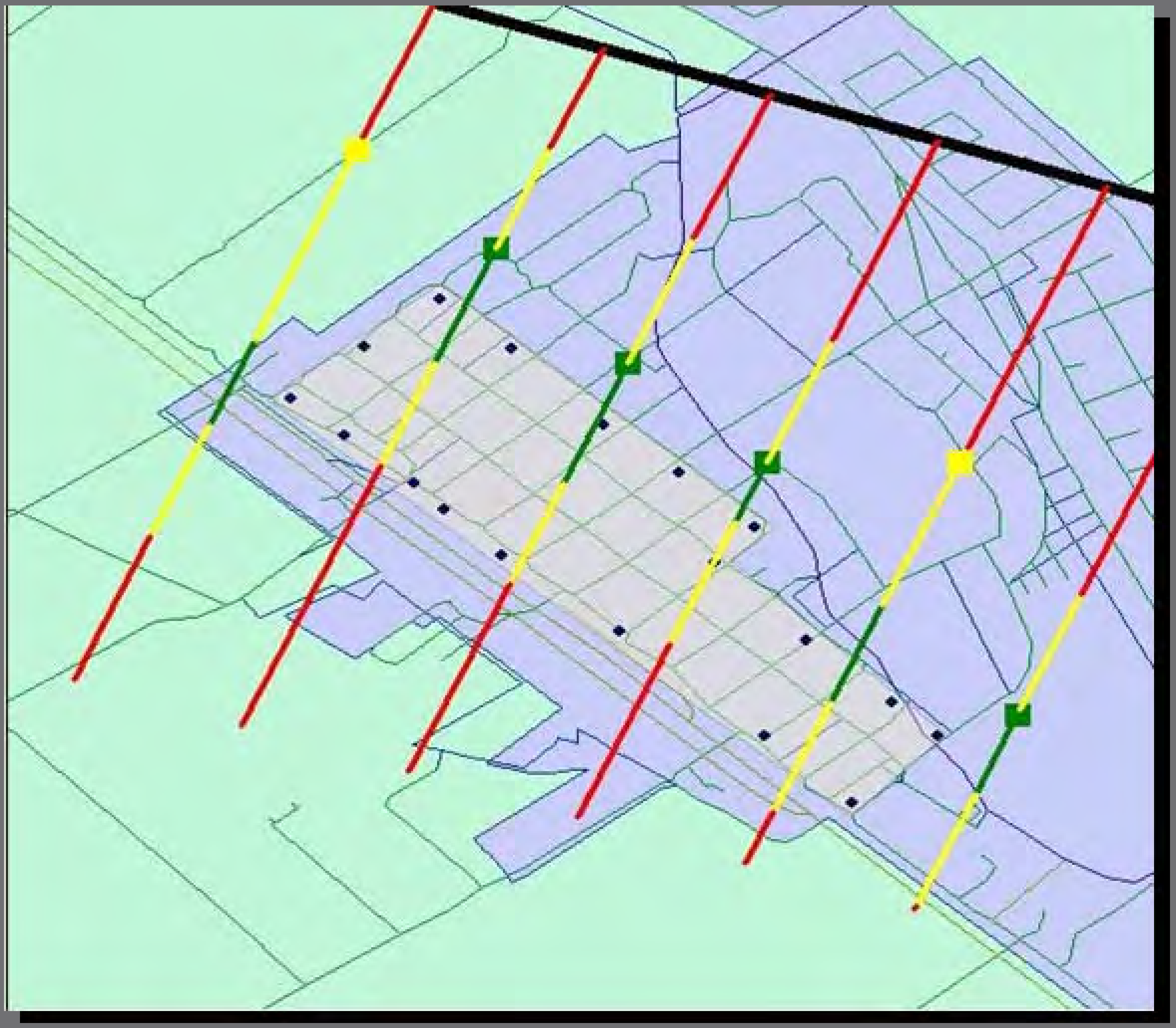




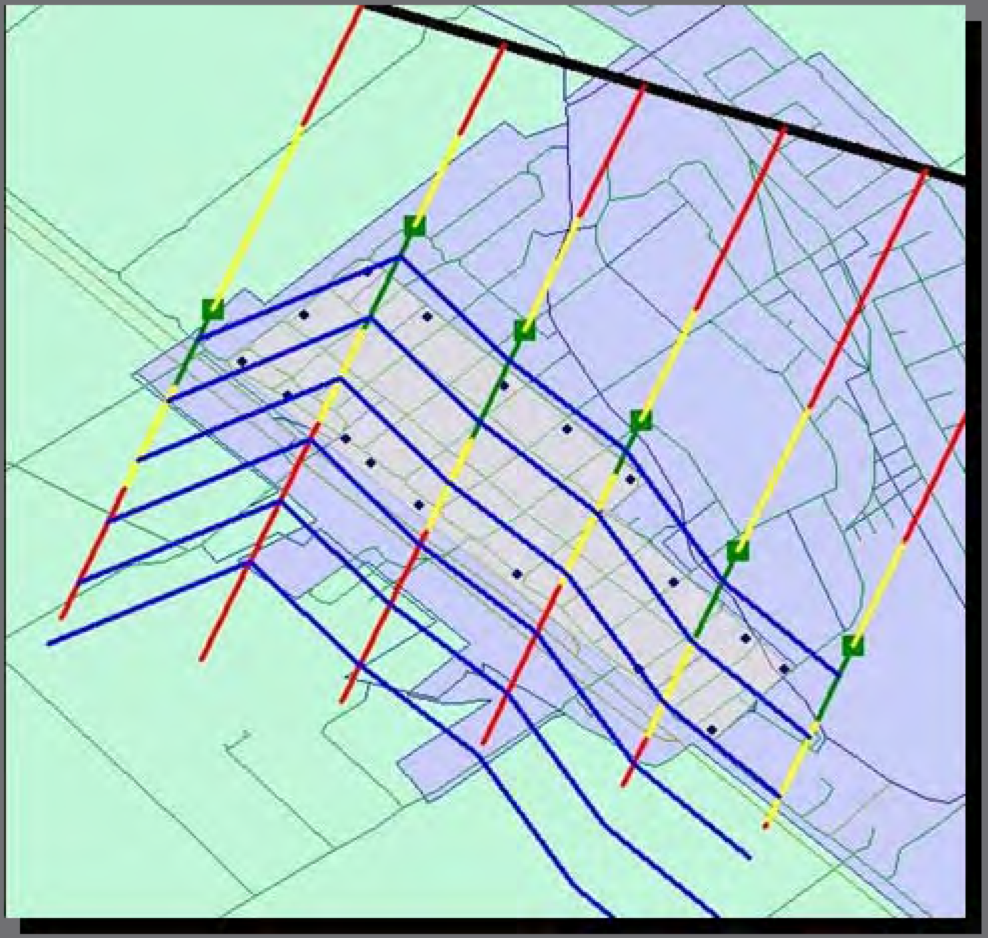
ARP Module



ARP Module



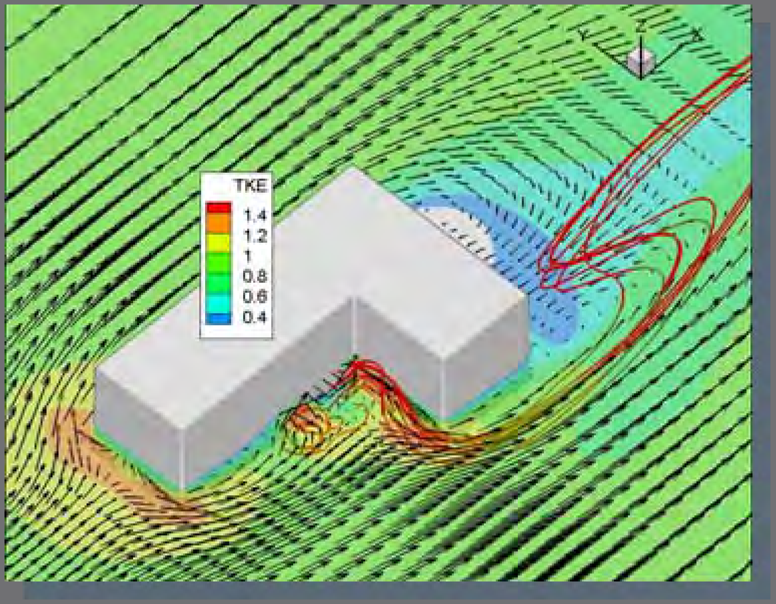
ARP Module



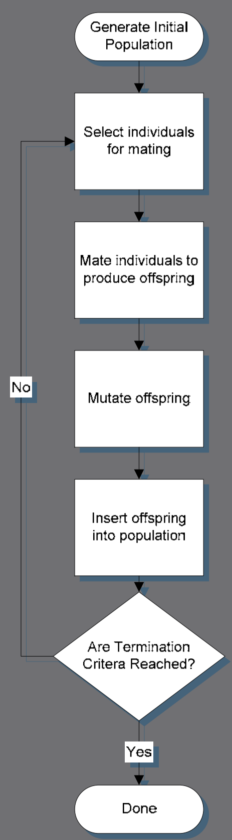
SLOTS Automated Rules-based Placement

Shortcomings of rules-based placement

- Inability to adequately address battlespace environment
- Inability to adequately account for multiple constraints
- Inability to account for a mixed sensor kit

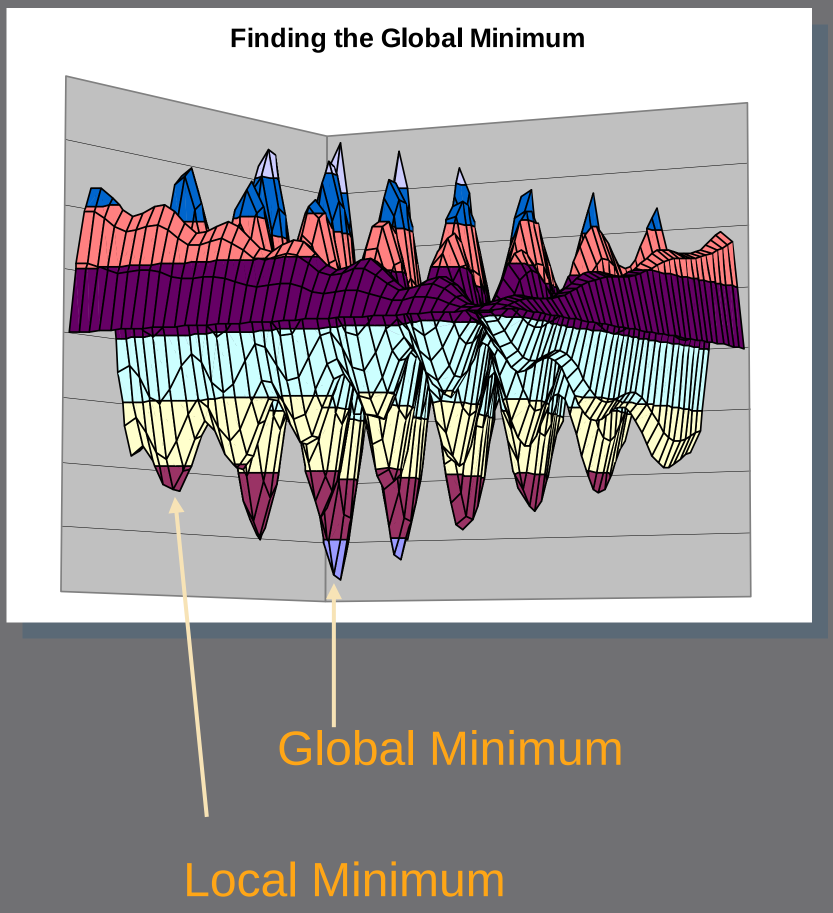


Sensor Placement Optimization
Genetic Algorithm



Advantage of Genetic Algorithms

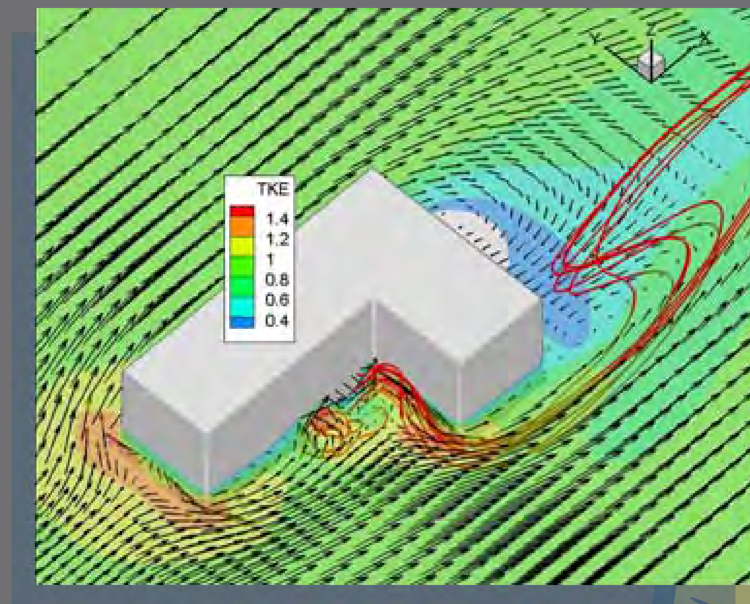
- Take into account multifaceted battlespace environmental effects
- Optimize placement based on operational mission objectives (performance criteria) with consideration for battlespace limitations (constraints)
- Enable multi-objective optimization

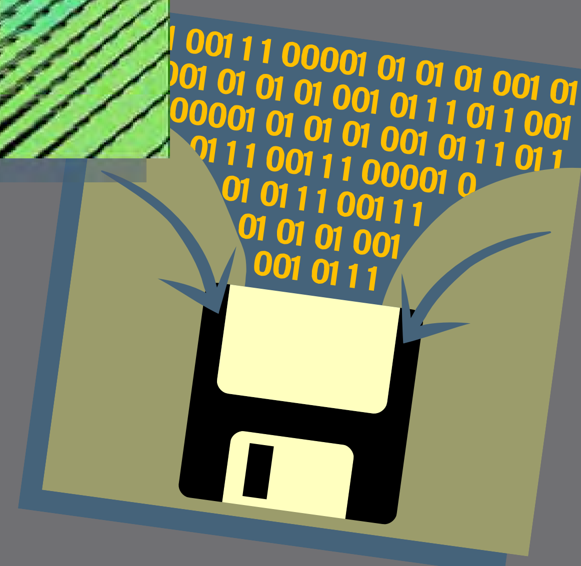


Sensor Placement Optimization
Genetic Algorithm

Challenges

- very large sets of data
- time required to generate this data





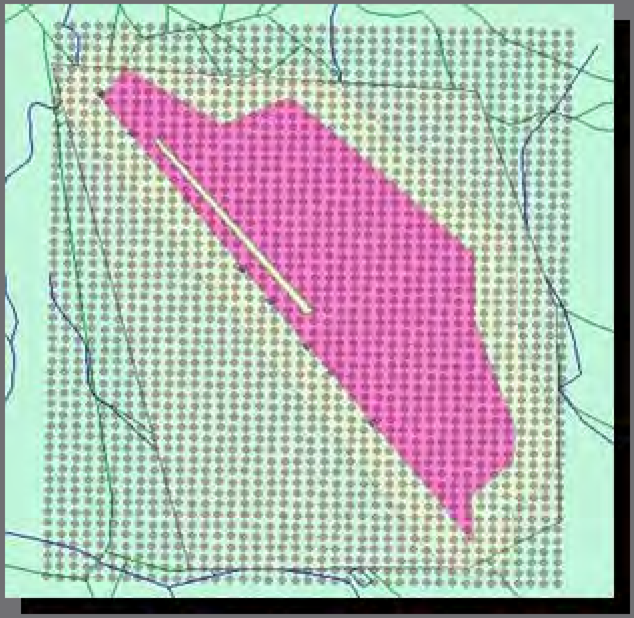
Simulation & Sensor Modeling

- NCBR II
  - Simulates multiple CB simultaneously in real time
  - Validated physics-based models for hazard propagation - DTRA's SCIPUFF
  - 4D met
  - 3D terrain

- DAS-A (Dial-A-Sensor – Analyzer)
  - Simulation tool for representing any CB particle and vapor sensors
  - Point and stand-off
  - Active and passive systems
  - Capability to "dial" parameters to set performance characteristics for each detector family

Sensor Grids

- The bulk of the optimization time is spent in the simulation and sensor modeling phase.
- To minimize this, we
  - Separate the hazard from the sensor modeling
  - Separate the sensor modeling from the optimization
- By creating many possible sensor placements and analyze the results for all of them.
  - Sensor placements are defined on a grid.
  - Uniform 2D grids have been used thus far.
- The GA then finds the optimal within the grid.



Scoring the Results

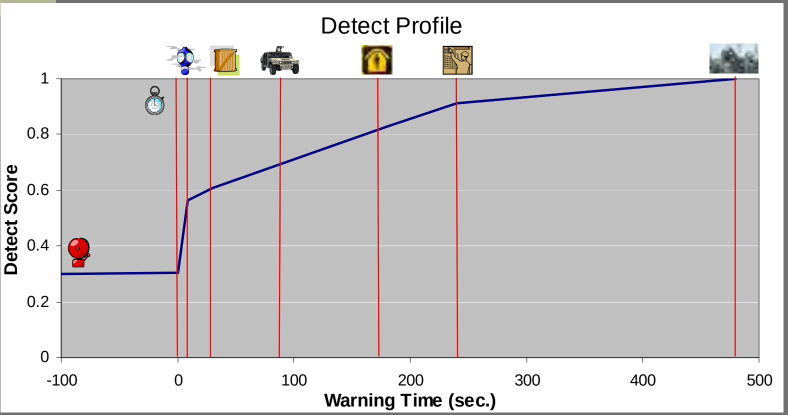
$$fitness = \sum_{threat}\left[w_{threat} \cdot \sum_{CA}\left(w_{CA} \cdot f\,(sensors, alarms_{threat}, alarms_{CA})\right)\right] \cdot \mathrm{Constraint}(sensors)$$

- Combines
  - Threats
    - Agent
    - Delivery
    - Attack placement
    - MET
  - Critical Asset
- Weighting values:
  - Attack Threat
    - Agent vulnerability
    - Agent Likelihood
    - MET Probability
  - Critical Asset importance

- Scoring function determines how complete preparations should be at any given time.
- Determine applicable preventative measures
  - Importance of action
  - Time required to enact

Activity	Required Time (sec)	Relative Importance
Detect	N/A	5
Zero Warning	0	1
Mask	9	6
Shelter Critical Supplies	30	1
Shelter Critical Equipment	90	2
Personnel move to shelter	180	3
Shutdown Building HVAC	240	2
Suit up	480	2

Sample User Defined Values



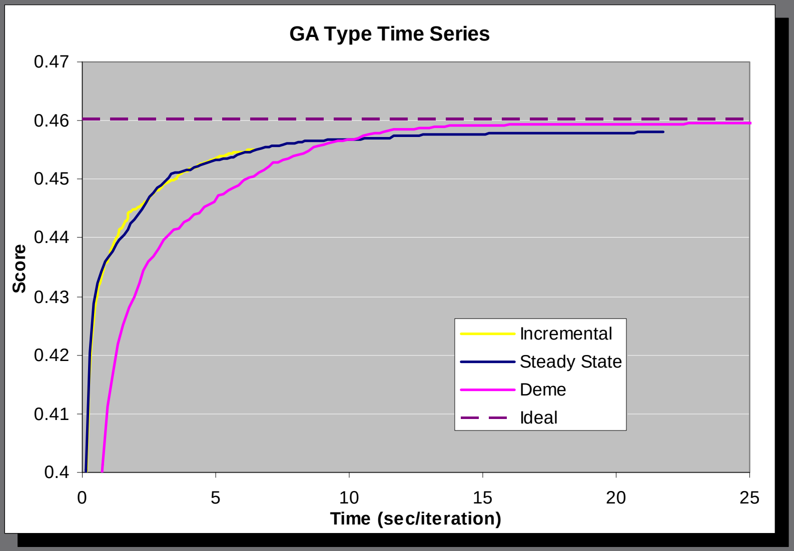
Constraints & TTP

- Hard (Fatal) Constraints
  - Areas where a sensor cannot be placed
  - Solutions edited or removed before continuing
  - Ex. Facilities, Lake, Roadways
- Soft Constraints
  - Areas where we don't want to put the sensor
  - But could if it were a good solution
  - Score penalized
  - Ex. Marshland, unprotected area

<u>Site Selection</u>
Lt. yellow – CA
Pink – Perimeter
Lt. Green – Constraint
(Max. Sensor Distance)

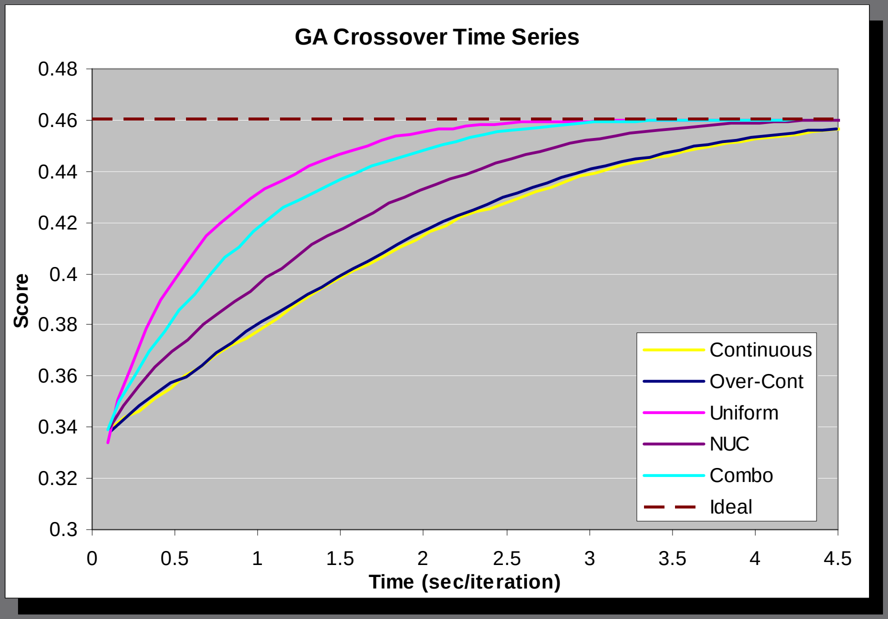
Genetic Algorithm

- Investigated performance of different GA implementations.
  - The ***Steady State*** implementation is the standard one.
  - The ***Incremental*** generates a pair of solutions for each generation instead of creating a nearly-new population.
  - The ***Deme GA*** is similar to the Steady State but uses several independent sub-populations and allows 'migration' of good solutions between these.
- **Performance:** The Deme takes longer to converge, but for the test problem it consistently produces the ideal solution, which is not true of the other two.



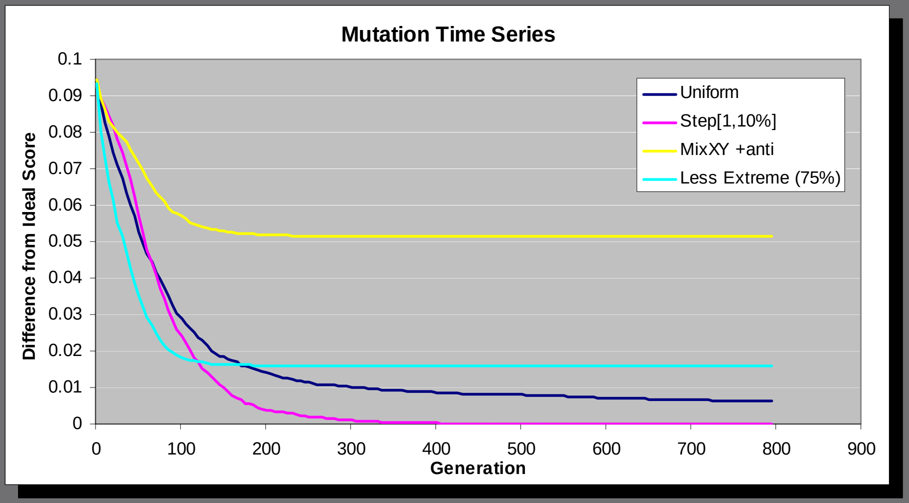
GA Crossovers

- Tested Several Crossovers: Uniform, Continuous, Over-Continuous, Non-Uniform Continuous, and combinations.
- **Performance:** In the test model, Uniform and Non-Uniform Continuous converged quicker than the Continuous & Over-Continuous crossovers.
- A combination of Uniform and Continuous crossovers randomly chosen has been the crossover of choice.



GA Mutations

- Tested many Mutations: Uniform, n-Steps in a Cardinal Direction, Picking a gene from a good solution, moving to (or toward) an extreme, and combinations.
- **Performance:** A rule of thumb for the ideal mutation rate is $(2*\text{Sensors})^{-1}$. Testing shows this to be fairly accurate.
  - Convergence with the Uniform mutator is slow.
  - Pick a gene speeded convergence early, but hindered convergence to the global optimum.
  - The effectiveness of the Step mutator varies by the step size.
  - The extreme mutator can be helpful, but is solution dependant.
  - A mixture of methods helped.

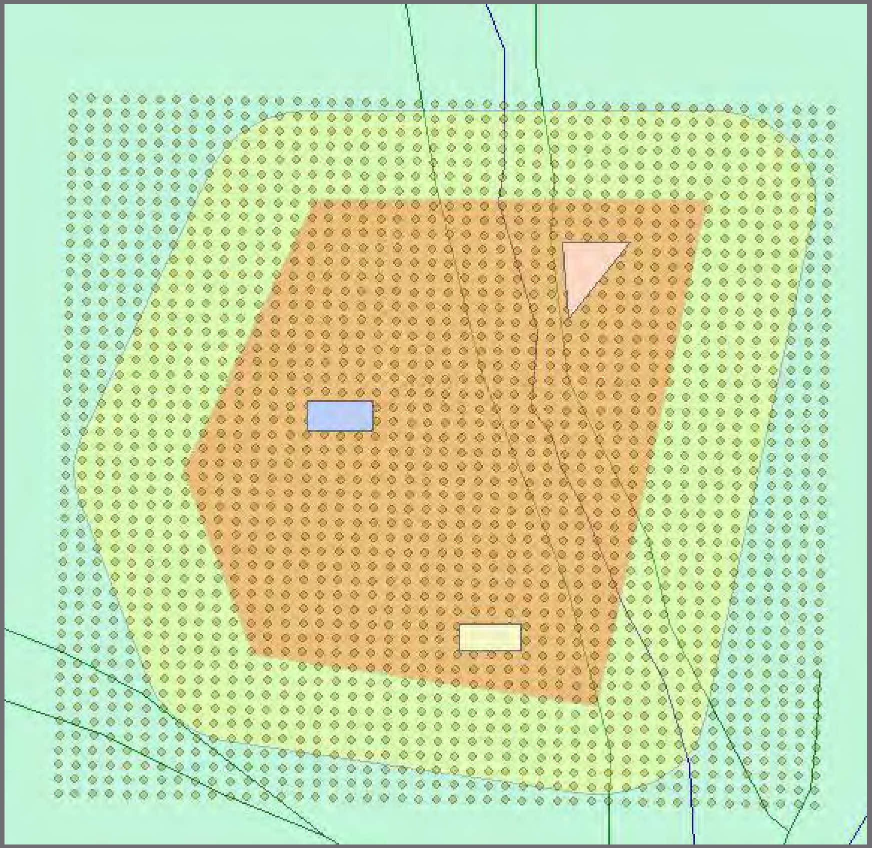


SLOTS GA Test

- Fort Hunter Liggett
- Rolling Hills
- Multiple Critical Assets
- Single Agent: GB
- Delivery
  - Scud (500kg)
  - 122mm Artillery Volley
  - 100kg Bomb
  - Line Spray from nearby roads
- Attack Placement
  - Several per Delivery & MET
- Using historic MET
  - Two wind directions (N, NNE)
  - Wind speeds at average + 1 standard deviation
  - Average Temperature
- 34 Simulations Total

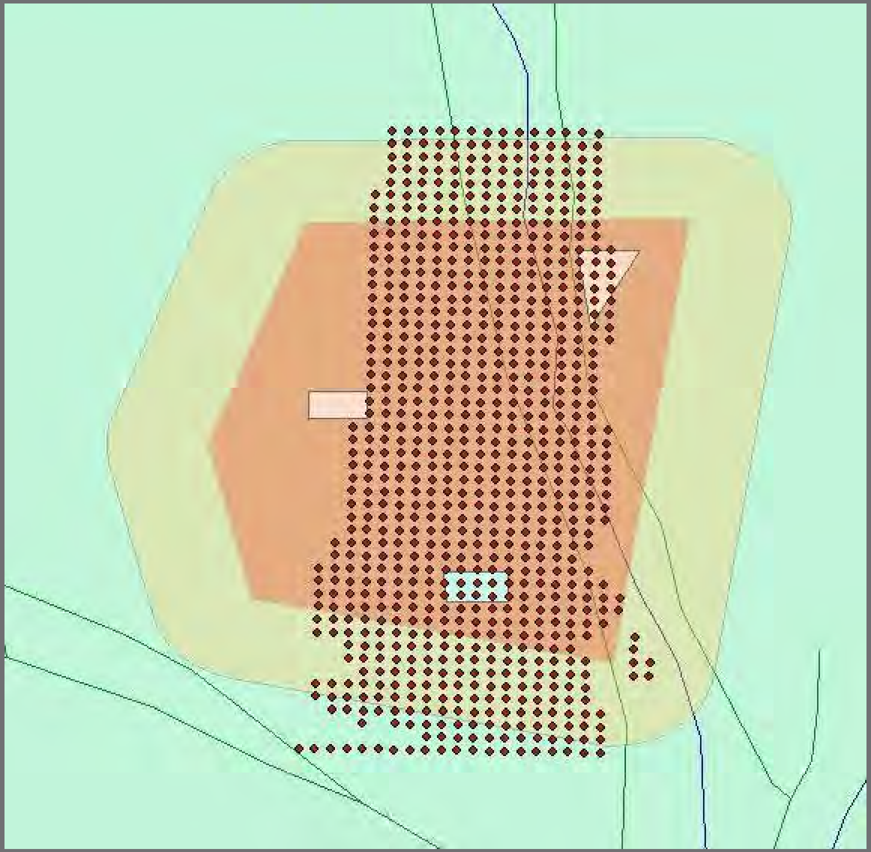
Optimization

- Layout
  - Grid (25m x 25m)



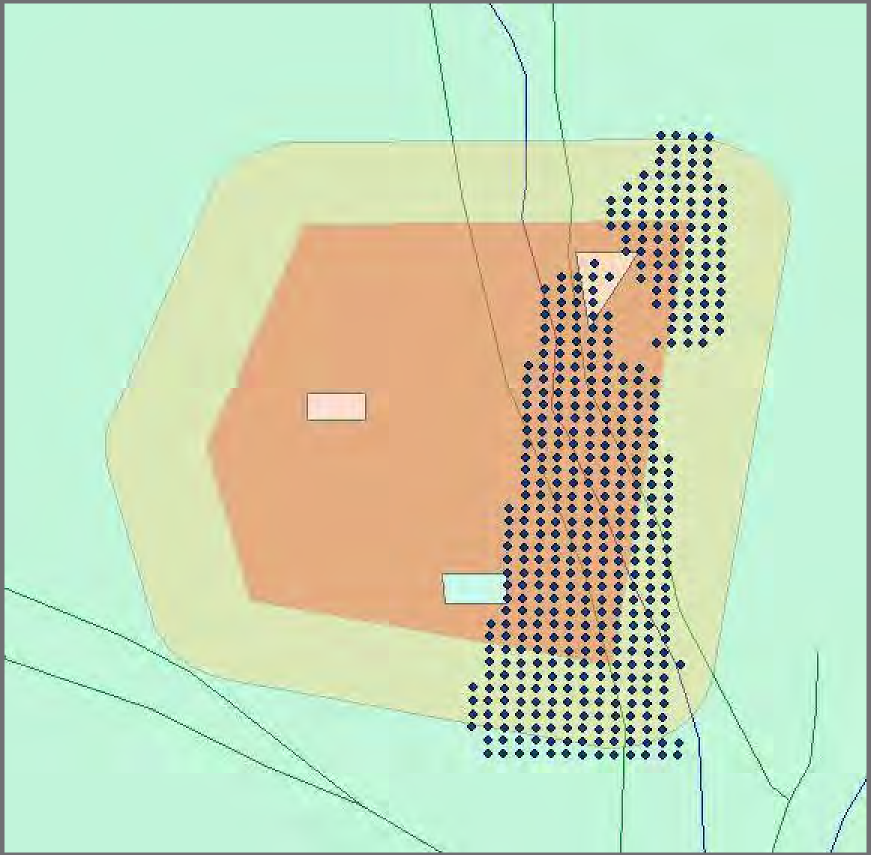
Optimization

- Layout
  - Grid (25m x 25m)
- Simulations
  - North Winds
    - Artillery @ 1100m



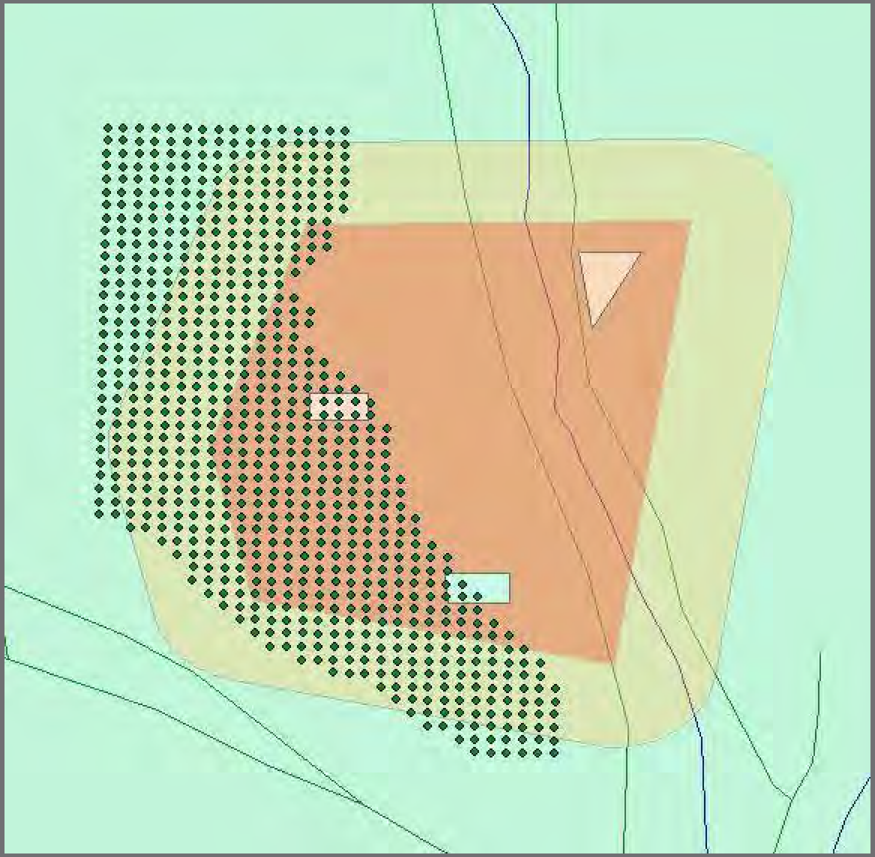
Optimization

- Layout
  - Grid (25m x 25m)
- Simulations
  - North Winds
    - Artillery @ 1100m
    - Line Spray @ 250-1500m



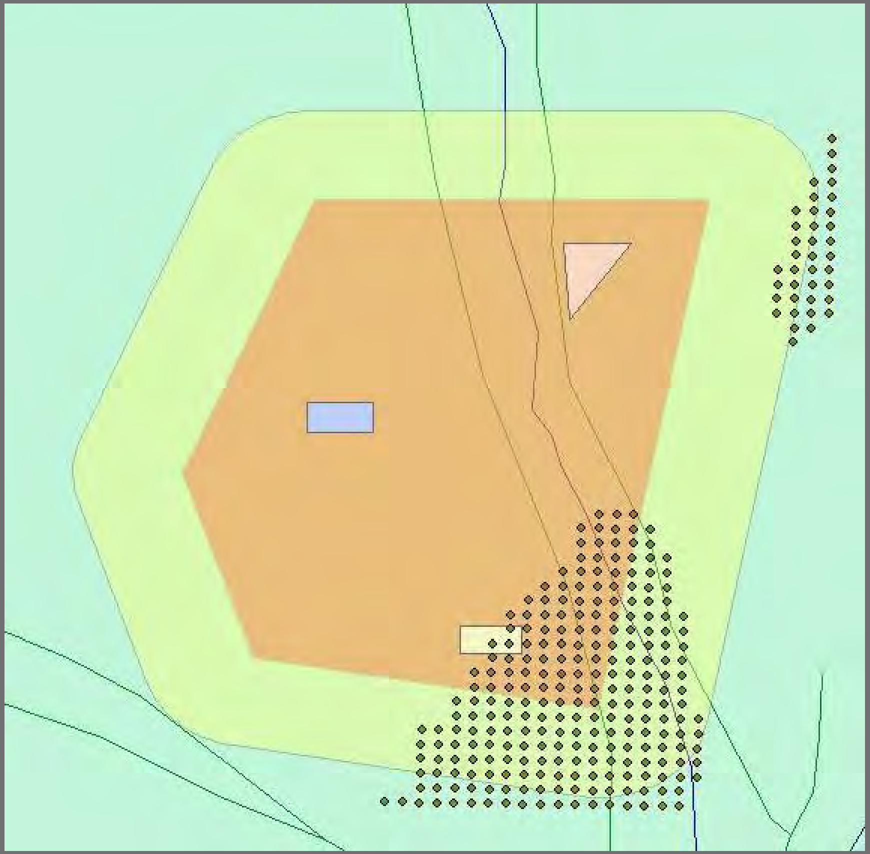
Optimization

- Layout
  - Grid (25m x 25m)
- Simulations
  - North Winds
    - Artillery @ 1100m
    - Line Spray @ 250-1500m
  - NNE Winds
    - Scud @ 2000m



Optimization

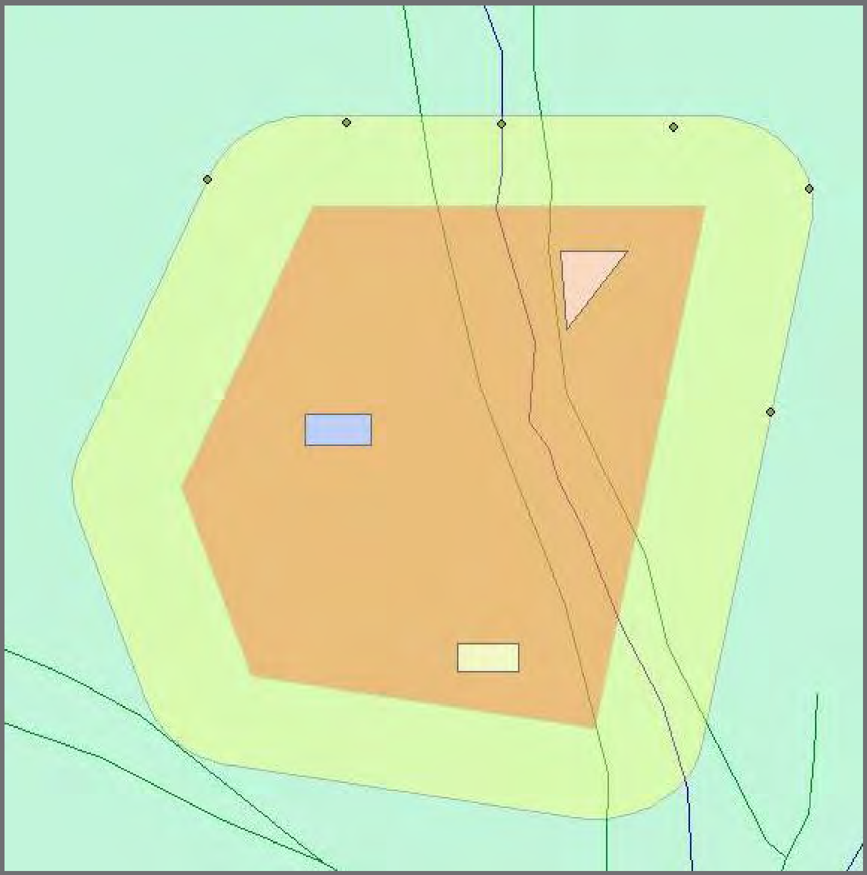
- Layout
  - Grid (25m x 25m)
- Simulations
  - North Winds
    - Artillery @ 1100m
    - Line Spray @ 250-1500m
  - NNE Winds
    - Scud @ 2000m
    - 100kg Bomb @ 500m

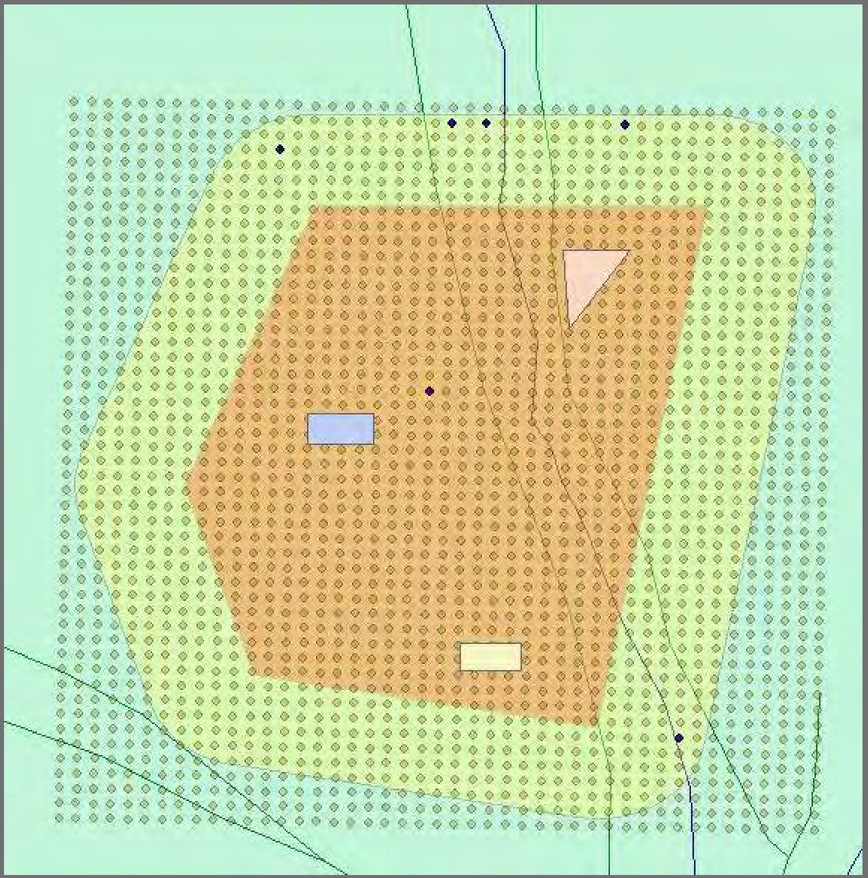


Optimization

- Layout
  - Grid (25m x 25m)
- Simulations
  - North Winds
    - Artillery @ 1100m
    - Line Spray @ 250-1500m
  - NNE Winds
    - Scud @ 2000m
    - 100kg Bomb @ 500m
- Optimal

Benchmark and Optimal





Benchmark

Score = 0.3814767

Optimal

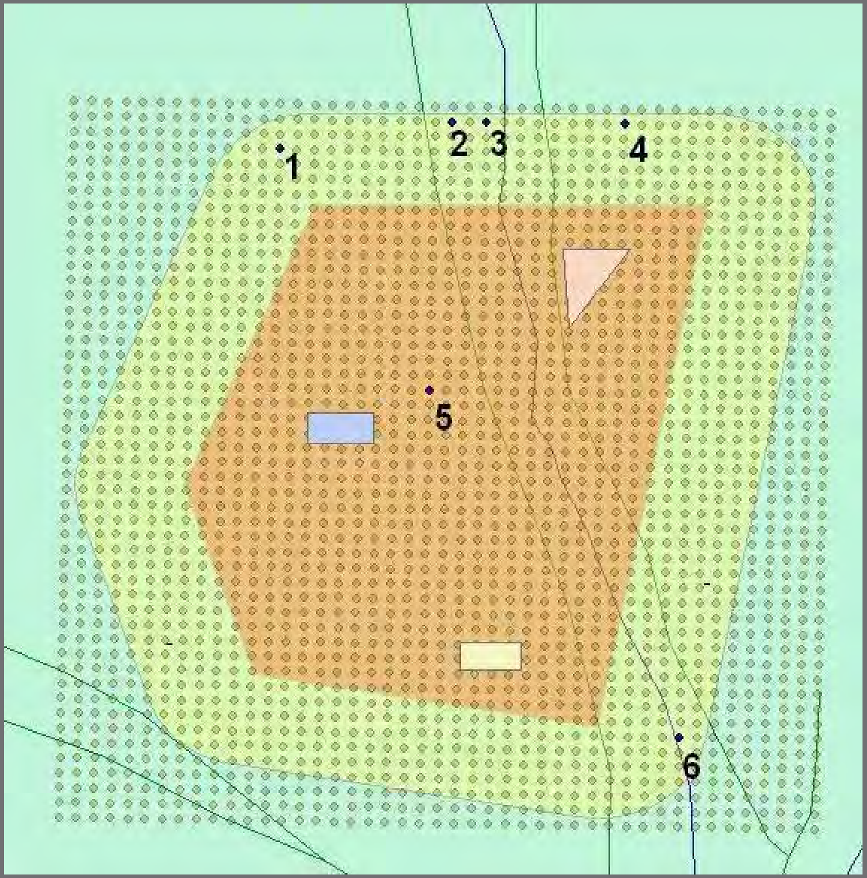
Score = 0.4719485

Why is the SLOTS generated Optimal solution better?

	Benchmark	Optimal
1st Sensor Detects	71	90
2nd Sensor Detects	30	58
3rd Sensor Detects	6	33
4th Sensor Detects	none	10
Undetected Asset Contaminations	17 assets on 9 attacks	0
# of Advance Warnings	58	64
Average Warning (sec)	134.2	125.9

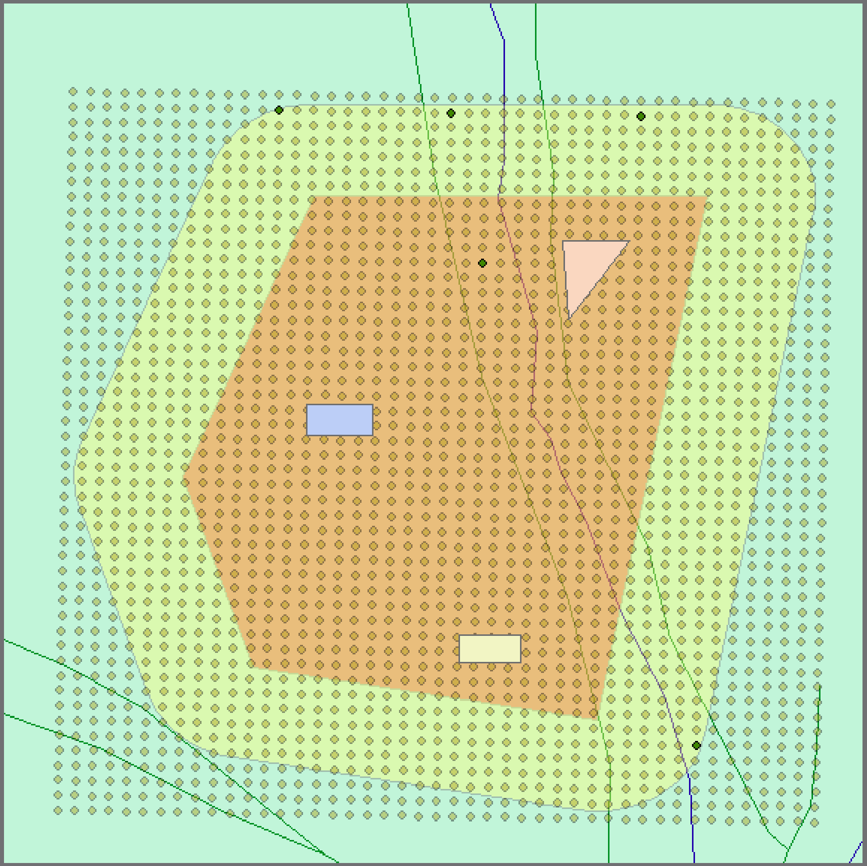
Why is that Sensor there?

- Sensors 1 & 6 are critical, they catch attacks with no other detection.
- Sensor 5 detects line spray attacks before the other sensors.
- Sensor 4 has the fewest detections, but almost all are 1st detects.
- Sensor 6 catches 6 of the 8 attacks the Benchmark misses.



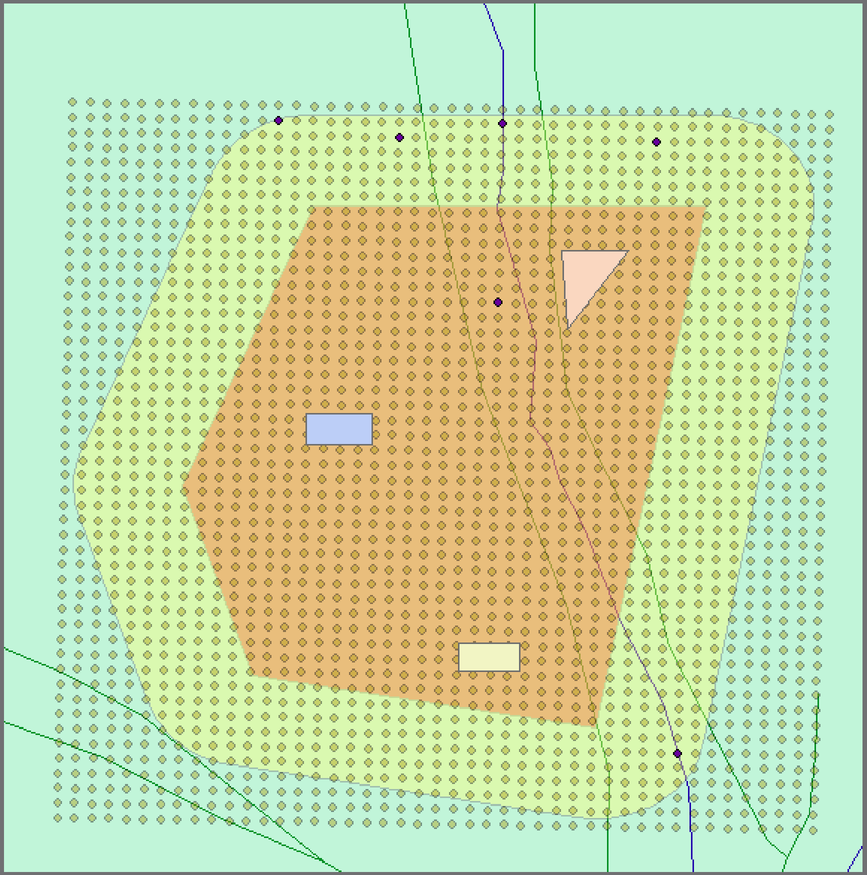
What happens with a smaller sensor kit?

- The sensor that is lost is from the Picket Fence.
- Interior and SW sensors retained.
- Fitness:
  - – 6 sensor = 0.4719485
  - – 5 sensor = 0.4509517
  - – 4.5% decrease



Adjacency Constraint

- Added a constraint to penalize sensors for being too close together.
- Exponential Decay function
- Fitness:
  - 6 sensor = 0.4719485
  - Adj Cnstr = 0.4668766
  - 1.0% decrease
  - Min distance > 150m

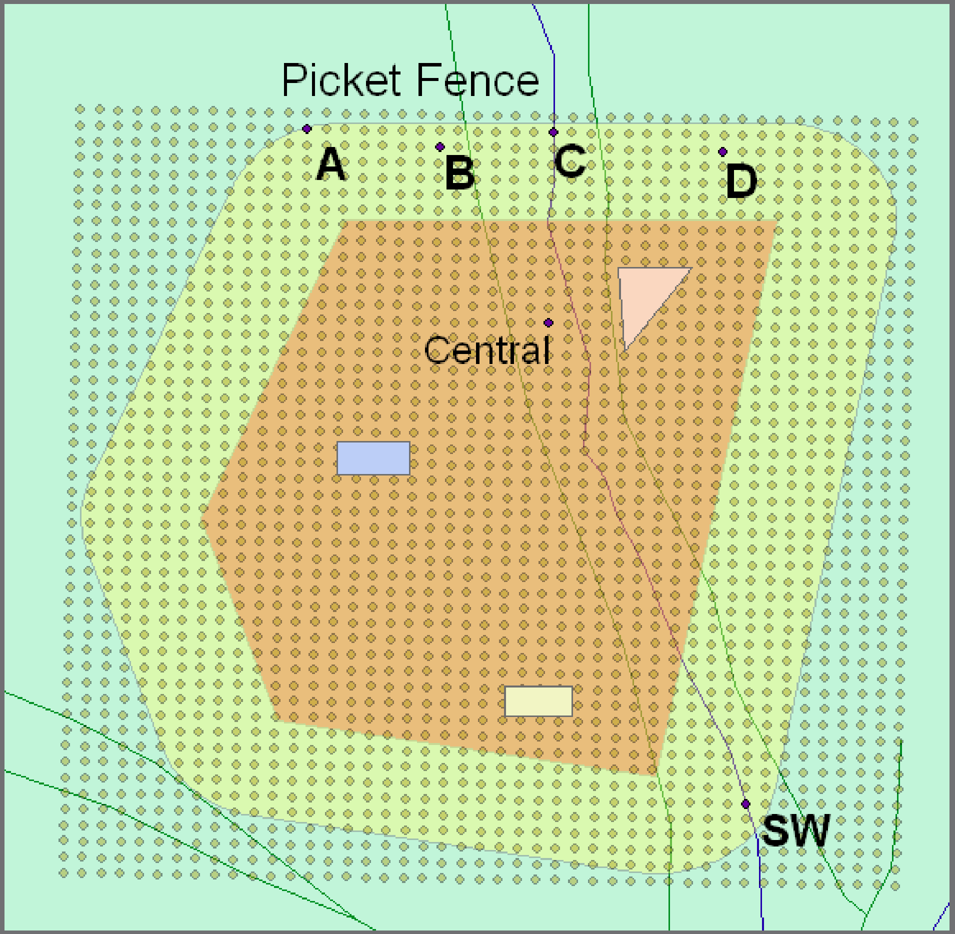


Why is the Optimal Better?

	Benchmark	Optimal	w/ Adj Constraint
1st Sensor Detects	71	90	90
2nd Sensor Detects	30	58	54
3rd Sensor Detects	6	33	23
4th Sensor Detects	none	10	7
Undetected Asset Contaminations	17 assets on 9 attacks	0	0
# of Advance Warnings	58	64	65
Average Warning (sec)	134.2	125.9	130.2

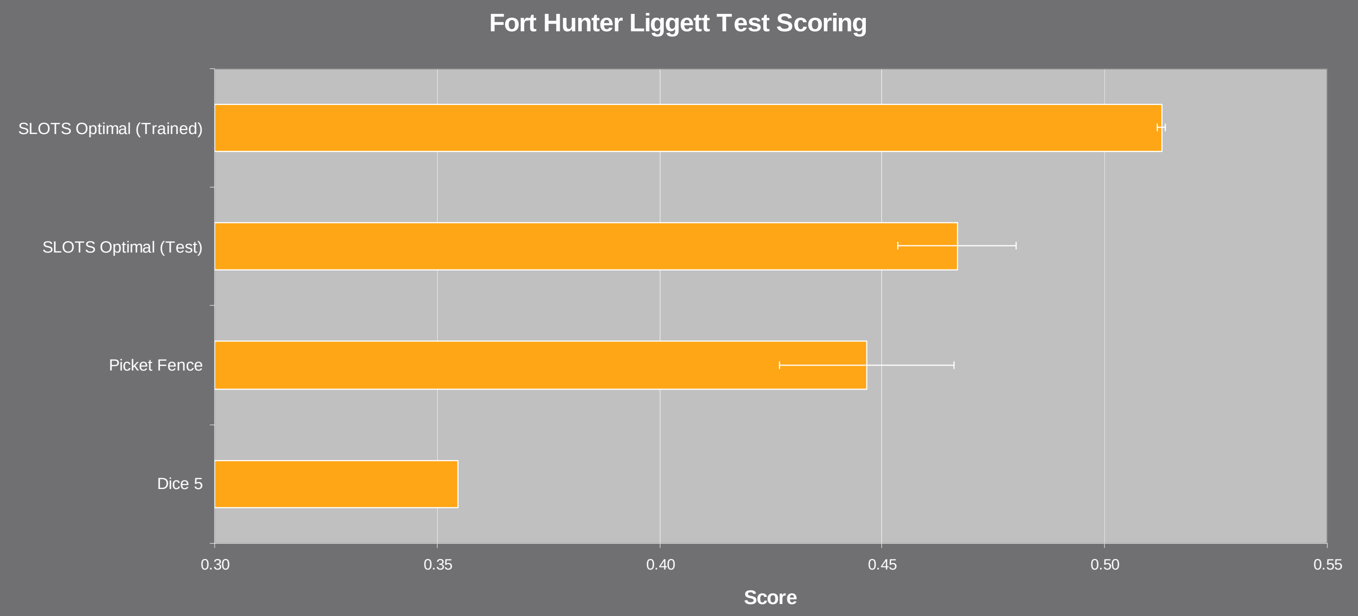
Why is that Sensor there?

- The SW sensor is critical.
  - Catches 69% of the attacks with no other detection
  - 11 first detects
  - Detects 44% of the attacks
- The Central sensor provides first detects for line spray attacks. And provides detects on 41% of attacks.
- The Picket Fence combines for 21 first detects with each sensor taking a fairly equal share.
- Picket Fence A has 19% of only detects.
- Picket Fence B detects 35% of all attacks

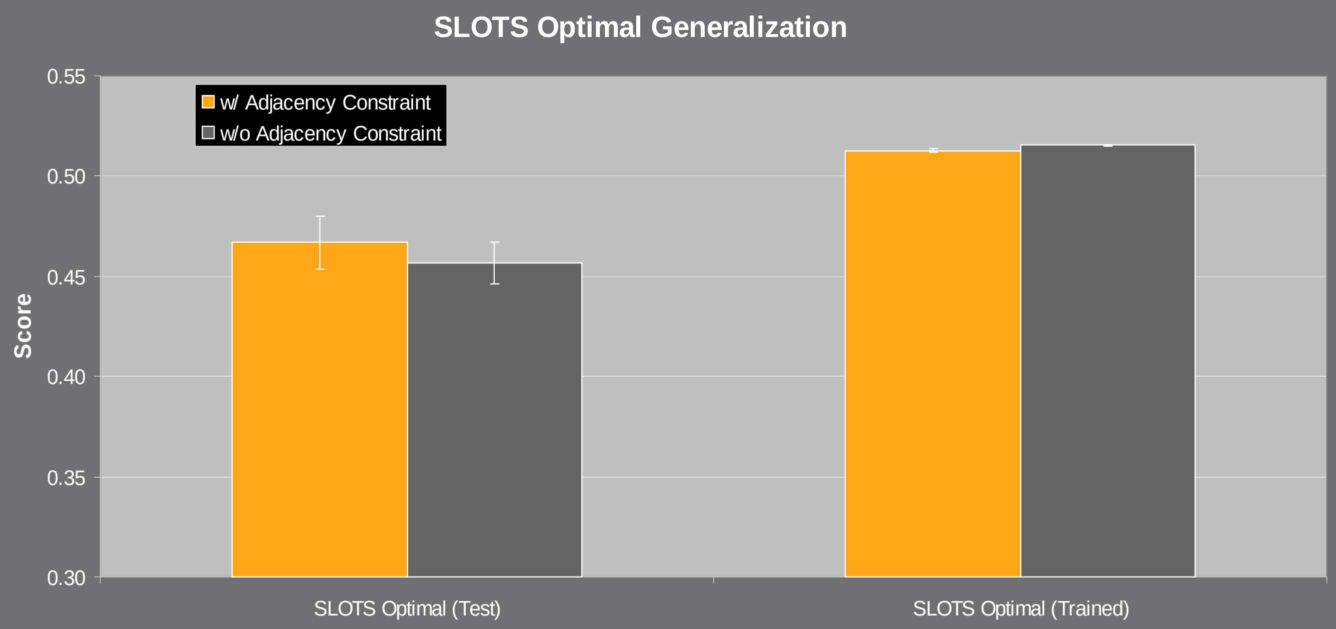


Does a SLOTS Layout *Generalize*?

- SLOTS optimal layouts are based upon a representative sample of attacks.
- How does it fare against attacks that it has not seen?
- Tested using Leave-one-out Cross-validation.
- Scores better than doctrine Methods

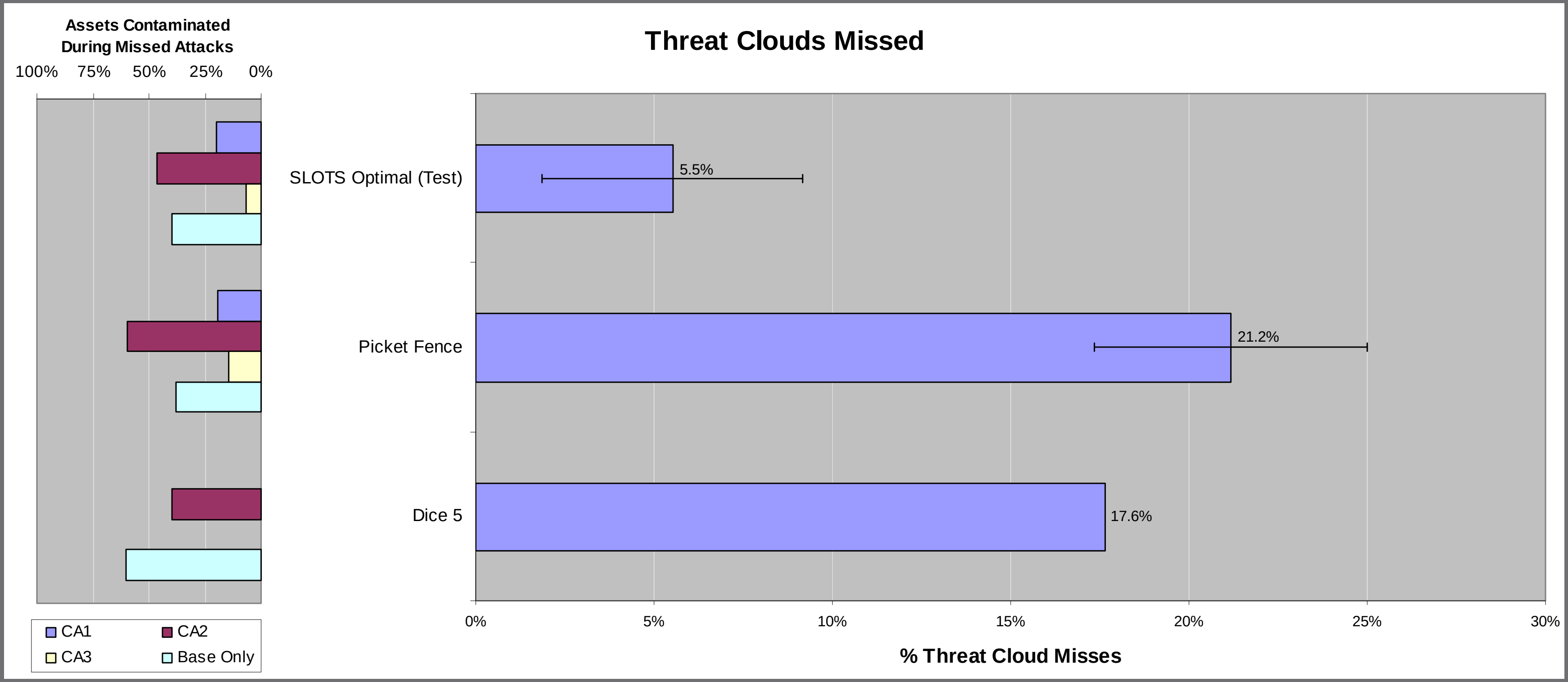


Generalization and Adjacency



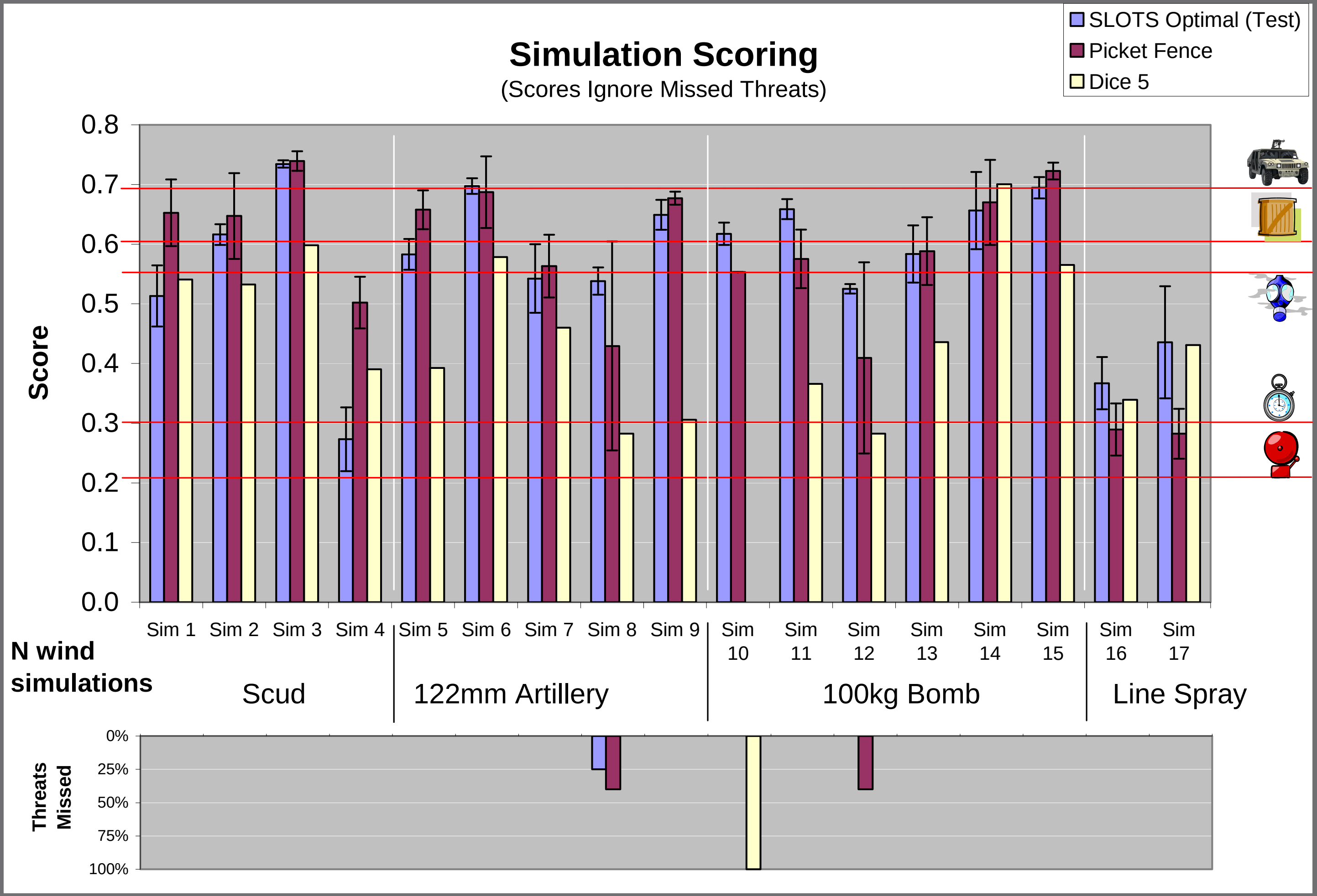
- Adding a common sense ‘Adjacency Constraint’
  - penalizes sensor layouts with sensors near one another
- Results in layouts with slightly poorer scores
- But cross-validated test scores improve by 2.2%

Threat Cloud Detection

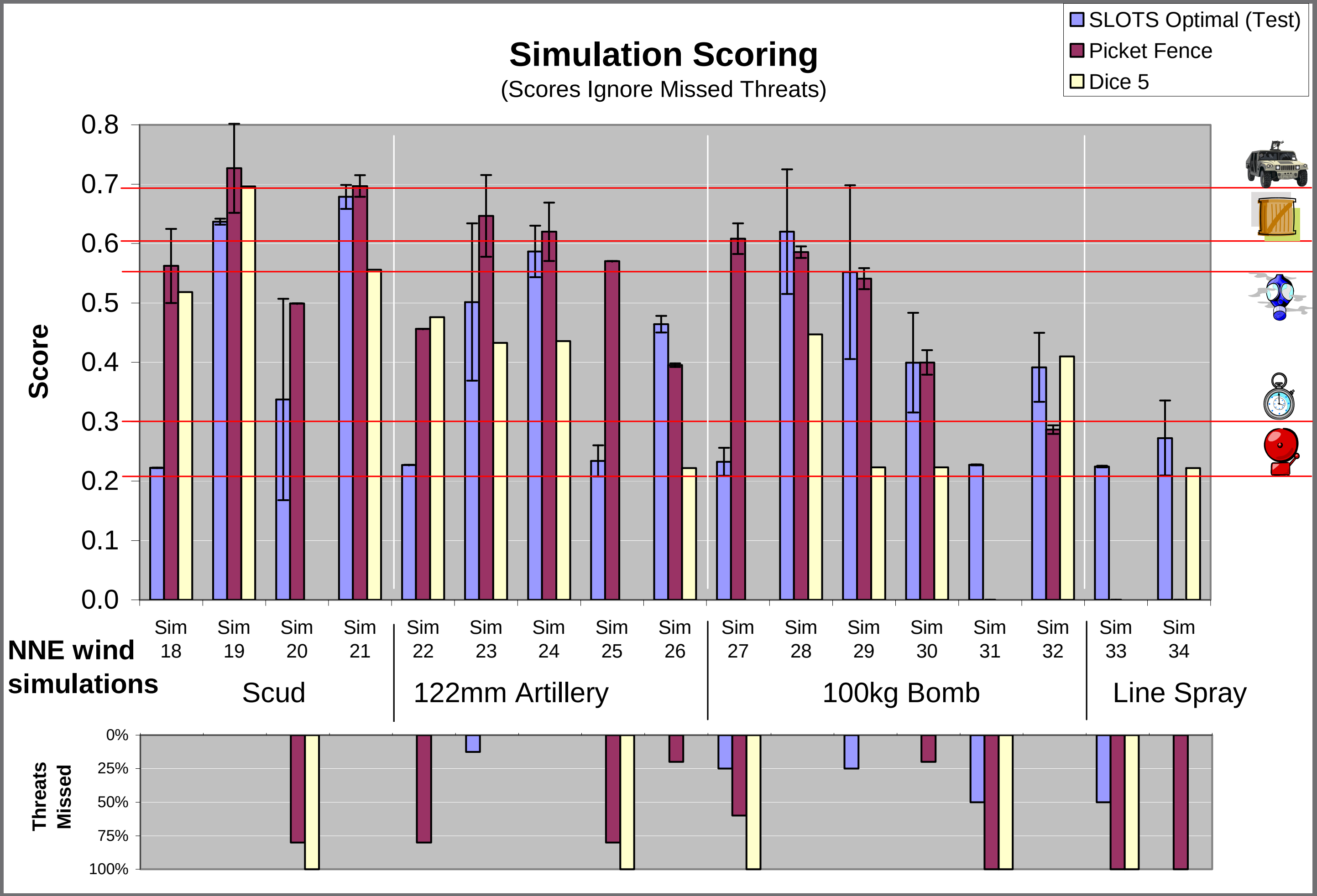


- SLOTS is able to detect threat clouds more reliably than doctrine.

Scoring Each Simulation



Scoring Each Simulation



Summary

- Automated Rules Placement Tool offers insight into the implications of implementation of sensor placement TTP
- Genetic Algorithms offer sufficient capability for optimizing sensor placement given
  - Constraints are defined
  - Performance criteria are understood
- Significant research still remaining

CBRN Data Import/Export Tool (CDIET)

Presented by:

Darius Munshi

Presentation Outline

- Introduction to CDIET
- Benefits provided to user
- Scope Statement
- Timeline for development and deliverables
- Core functionality provided to user
- Look and Feel
- Possible technologies that will be used
- What CDIET is NOT
- Risks and Risk mitigation
- Questions

Introduction to CDIET

- A two phase, a two year effort
- First release, CDIET Suite Version 2.0 to be delivered October 9, 2007
- Key Features
  - Platform independent solution
  - Multiple DB Access
    - Microsoft Access
    - SQL Server
    - Oracle
    - MySQL
  - Interface with JPM IS CBRN Data Model Schema
  - "Library" Design Allows Customizable Solution to Access the CBRN Data Model
  - Map Database with CBRN Data Model
    - Drag and Drop visual interface
    - Programmatically through a Java API

Benefits provided to user

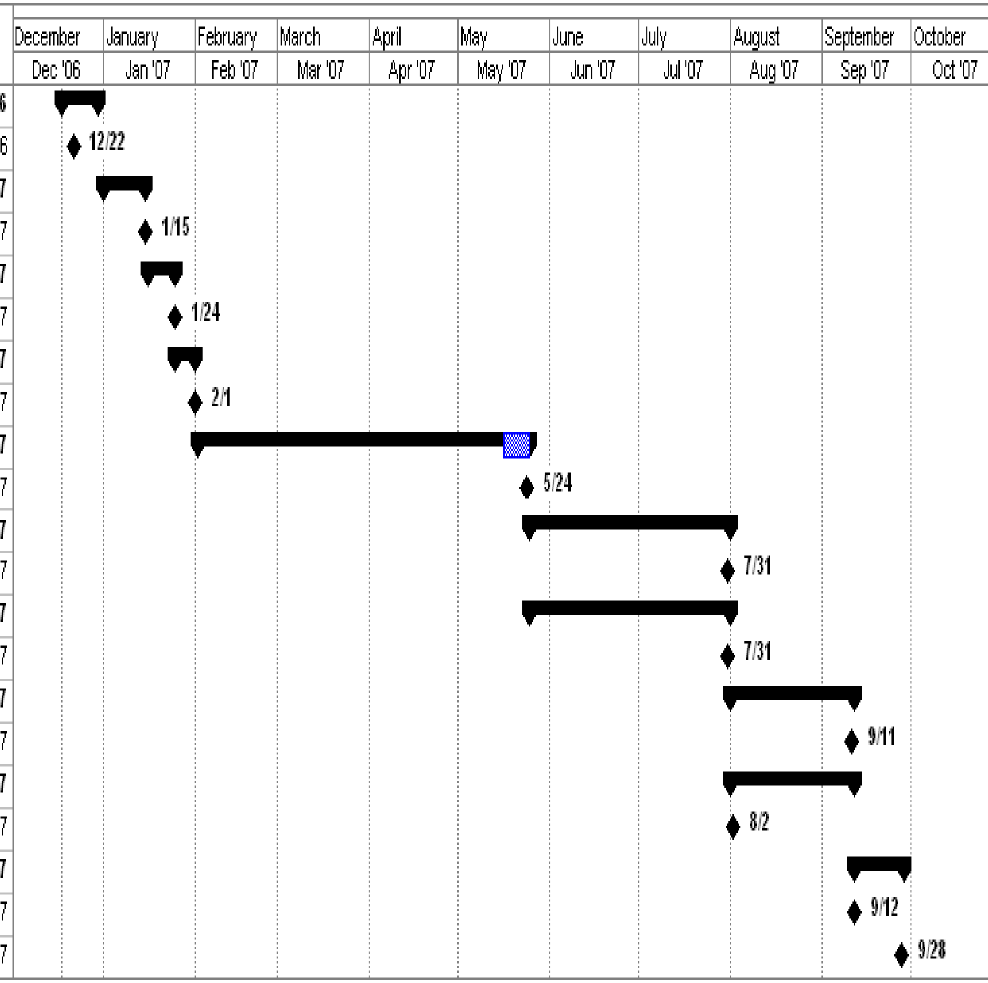
- Allow CBRN Applications to be quickly and efficiently adapted for Net-centric, XML data sharing effort
  - Data shared is their own legacy data, in CBRN Data Model Compliant Format
  - Automates the formatting of legacy data
- Targeted Data Processing
  - Allows members of CBRN community to focus on specific areas of the CBRN Data Model that relates to their current project or needs
  - Provides Dynamic Structured Query language (SQL) statement creation with user specified criteria
    - Share relevant data
    - Provide for creation of XML Data Documents free of unnecessary data
      - Increased efficiency and speed of data sharing
- Easy to Use
  - Easy, drag-and-drop interface
  - Abstracted, encapsulated API methods and functions

Scope Statement

- **CDIET will allow the Software Engineer to**
  - **Facilitate integration of an existing application with the CBRN toolset**
  - **Map legacy databases with the CBRN Data Model Schema**
  - **Import and export legacy data in CBRN Data Model compliant formats**
- **CDIET will provide**
  - **A visual, interactive stand alone Java application for the analyst community**
  - **A Java library for software engineers to use in their own applications to interface and work with the CBRN Data Model and their legacy database applications**

Timeline for development and deliverables

ID	Task Name	Duration	Start	Finish
1	**Define Requirements**	**10 days**	**Mon 12/18/06**	**Fri 12/29/06**
4	Complete Scope, time, expertise available & PMP	0 days	Fri 12/22/06	Fri 12/22/06
6	**Design CDIET Java Library (CDIET JL v 1.1)**	**10 days**	**Mon 1/1/07**	**Mon 1/15/07**
8	Finalise design of CDIET JL v 1.1	0 days	Mon 1/15/07	Mon 1/15/07
9	**Design CDIET User Interface (CDIET UI v 1.1)**	**7 days**	**Tue 1/16/07**	**Wed 1/24/07**
12	Finalise design of CDIET UI v 1.1	0 days	Wed 1/24/07	Wed 1/24/07
13	**Design CDIET Database Security Tool (CDIET DST v 1.1)**	**5 days**	**Thu 1/25/07**	**Thu 2/1/07**
16	Finalise design of CDIET DST v 1.1	0 days	Thu 2/1/07	Thu 2/1/07
17	**Code and Implement CDIET JL v 1.1**	**80 days**	**Fri 2/2/07**	**Thu 5/24/07**
26	Complete CDIET JL v 1.1	0 days	Thu 5/24/07	Thu 5/24/07
27	**Code and Implement CDIET UI v 1.1**	**48 days**	**Fri 5/25/07**	**Tue 7/31/07**
33	Complete CDIET UI v 1.1	0 days	Tue 7/31/07	Tue 7/31/07
34	**Code and Implement CDIET DST v 1.1**	**48 days**	**Fri 5/25/07**	**Tue 7/31/07**
39	Complete CDIET DST v 1.1	0 days	Tue 7/31/07	Tue 7/31/07
40	**CDIET Suite v 1.1 Testing**	**30 days**	**Wed 8/1/07**	**Tue 9/11/07**
42	Finish CDIET Suite v 1.1 Testing	0 days	Tue 9/11/07	Tue 9/11/07
43	**Documentation**	**30 days**	**Wed 8/1/07**	**Tue 9/11/07**
46	Complete all user documentation	0 days	Thu 8/2/07	Thu 8/2/07
47	**Product Delivery**	**13 days**	**Wed 9/12/07**	**Fri 9/28/07**
48	Deliver CDIET Suite v 1.1 CD-ROM	0 days	Wed 9/12/07	Wed 9/12/07
50	Customer acceptance	0 days	Fri 9/28/07	Fri 9/28/07



Timeline for development and deliverables (cont)

- **Schedule Synopsis**

– Complete Design and Architecture of all components	February 1, '07
– Complete CDIET Java Library (CDIET JL v 2.0)	May 24, '07
– Complete CDIET User Interface (CDIET UI v 2.0)	July 31, '07
– Complete CDIET Database Security Tool (CDIET DST v 2.0)	July 31, '07
– Deliver to Customer for Customer Acceptance Testing	September 12, '07
– Final Delivery, Project Closure	October 9, '07

- **Follow-on, Second phase 2008**

– Customer needs and requirements gathering	October '07 – January '08
– Complete CDIET Suite 3.0 Scope, Design, and Architecture	March '08
– CDIET Suite 3.0 Development	March '08- August '08
– Deliver to Customer for Customer Acceptance Testing	September '08
– Final Delivery, Project Closure	October '08

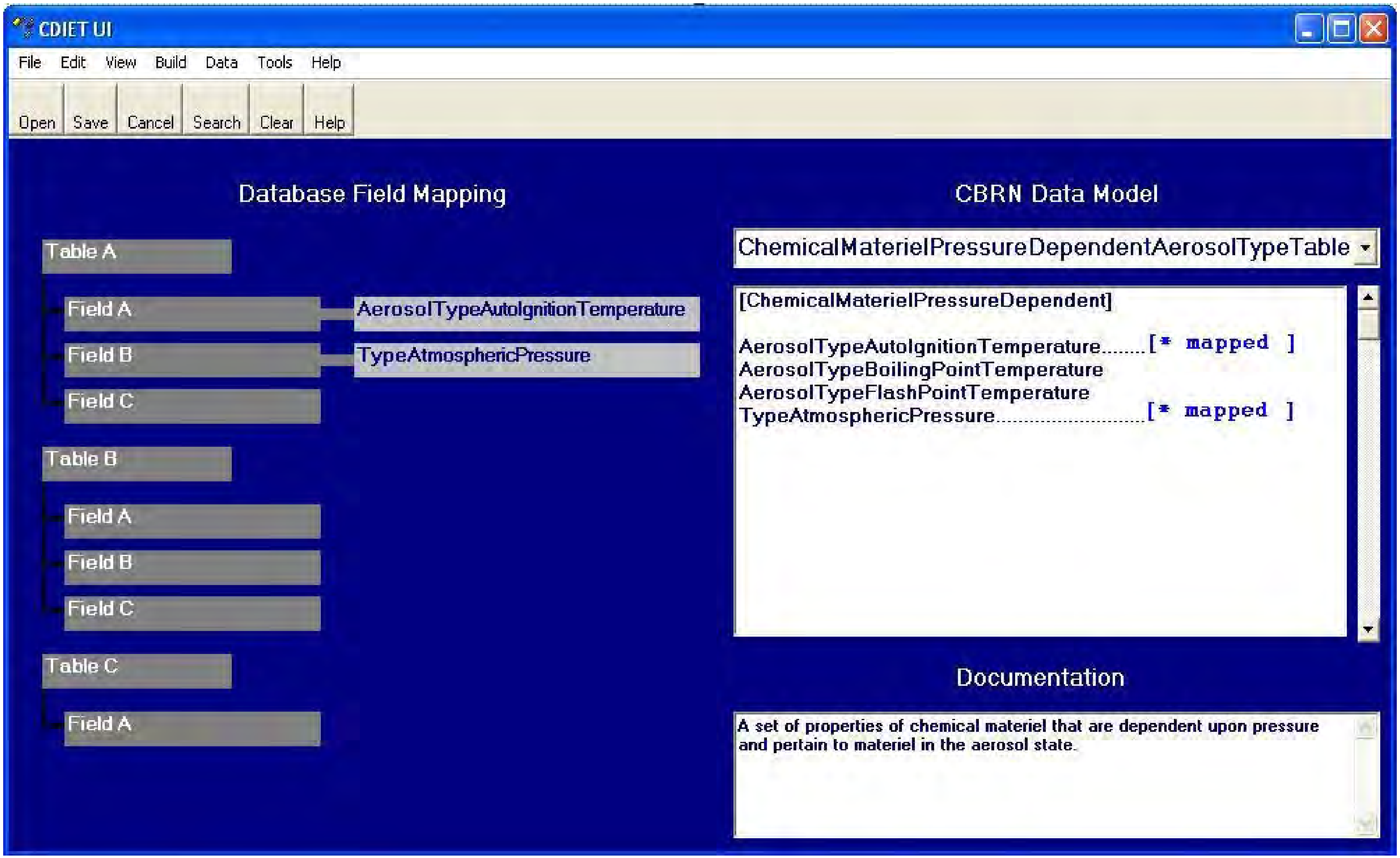
Core functionality provided to user

- CDIET Component Suite v 2.0
  - Gather information about user's database automatically
    - Field names
    - Table names
    - Constraints and data types
  - Gather information about the CBRN Data Model automatically
    - Element names and values
    - Embedded documentation
  - Support the following relational database systems
    - SQL Server
    - Microsoft Access
    - MySQL
    - Oracle

Core functionality provided to user

- CDIET Component Suite v 2.0
  - Provides functionality to
    - Map user’s database with CBRN Data Model with a user friendly GUI
    - Produce XML data documents in CBRN Data Model compliant formats
  - Provides database search capability of
    - Element names and embedded documentation in the CBRN XML schema
    - Field names and table names in the legacy databases
  - Provides all functionality through API and GUI
    - Programmatically for the software engineer
    - Graphical user interface for other users

Look and Feel



CDIET UI Component, Prototype Version

Possible technologies that will be used

- **Native-protocol all-Java driver**
  - **Pure Java database interface built on Java Database Connectivity (JDBC) driver**
  - **Near universal access with legacy databases**
  - **Does not rely on platform dependant implementation, such as ODBC**
  - **High speed, high performance database access**

Possible technologies that will be used

- **Xerces2 Java Parser**
  - **Component of the Apache XML Project**
  - **High speed, high performance XML parser**
  - **All Java, platform independent tool that can be used to parse XML data documents**
    - **CBRN Data Model's XML Schema**

What CDIET is NOT

- **CDIET is NOT**
  - **A Sea Diet consisting of Seafood**
  - **A tool that provides transmission of data across a network**

Risks and Risk mitigation

- Minimize Scope Creep
  - Formal Project Management Document that includes all and only the functionality CDIET will provide
  - Support for only a subset of legacy database formats for the first release
    - MS-Access
    - SQL Server
    - Oracle
    - MySQL

Questions

Waterborne Chemical Agent Transport Modeling Capability

2007 Chemical Biological Information Systems Conference and Exhibition
08-11 January 2007
Austin, TX

Matthew C. Ward, P.E.
Principal/Director of Defense Programs
Applied Science Associates
401-789-6224
wardm@appsci.com

Presentation Overview

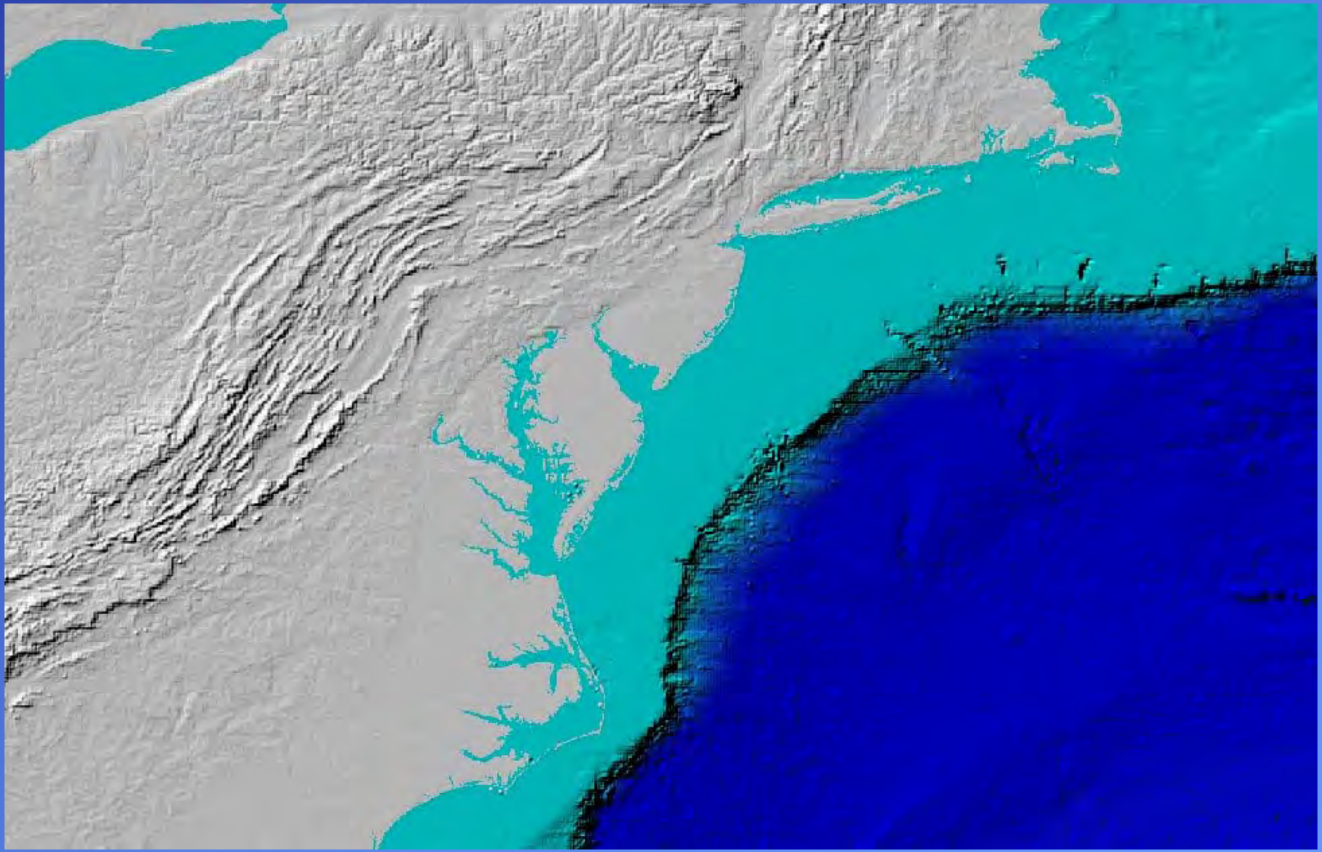
- Background
  - Why waterborne transport
  - Waterborne modeling data requirements
  - Data Availability
- Phase I SBIR
  - Objective
  - ASA Waterborne Chemical Transport Model
  - Integration Architecture
  - Results
- Phase II SBIR

Why Waterborne Transport

- Interdiction at sea
- Active Defense
- Deposition from an atmospheric chemical plume to a water body
- Intentional or accidental release of a chemical agent into a water body
- **Implications of such events can involve**
  - Impedance of expeditionary forces into theater
  - Special operators mission effectiveness
  - Contamination of combatant vessels
  - Impact to drinking water supplies

Environmental Data Requirements

- **Land-Water delineation**
- Bathymetry
- Currents
- Temperature
- Salinity
- Winds



Environmental Data Requirements

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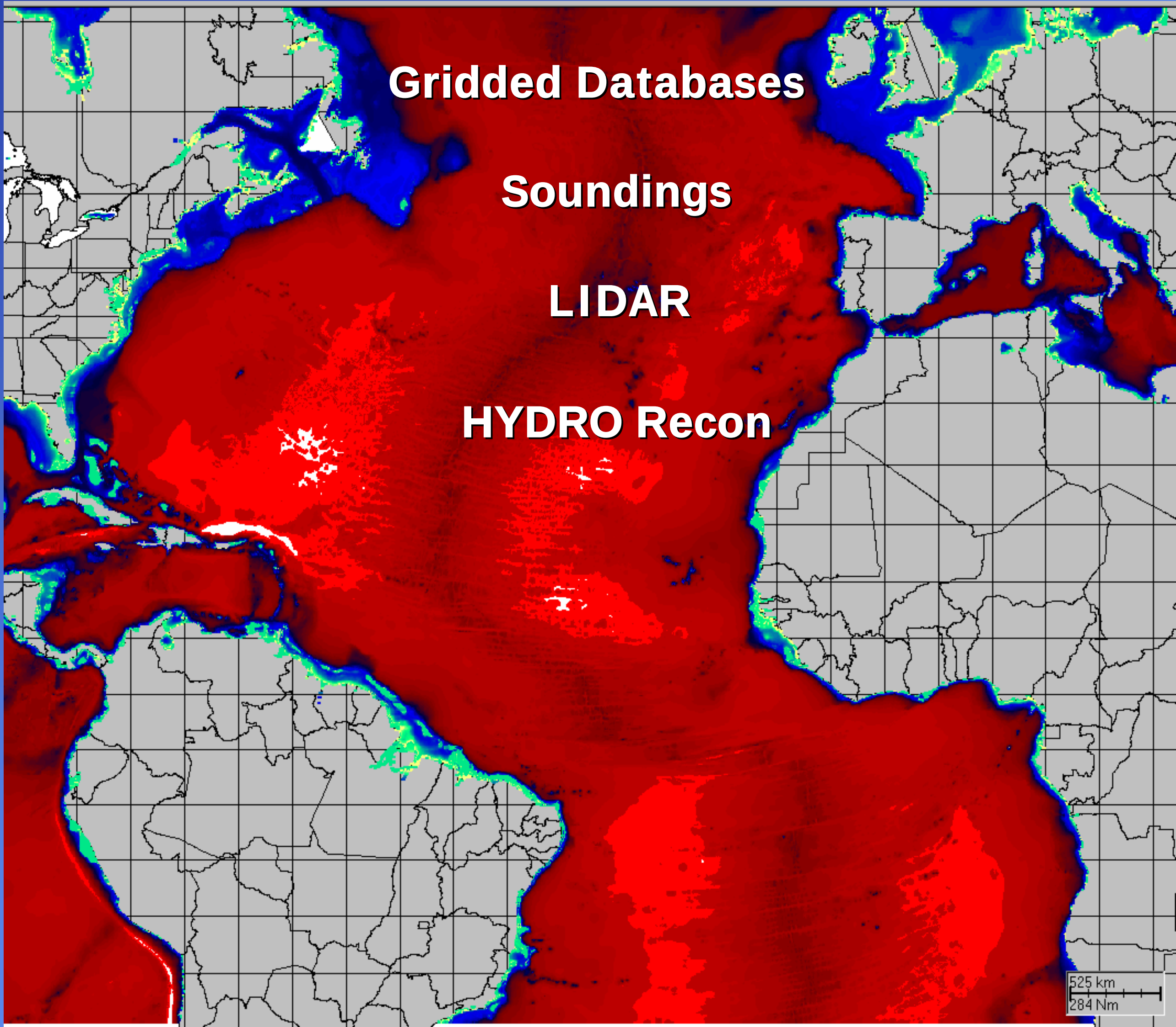

Environmental Data Requirements

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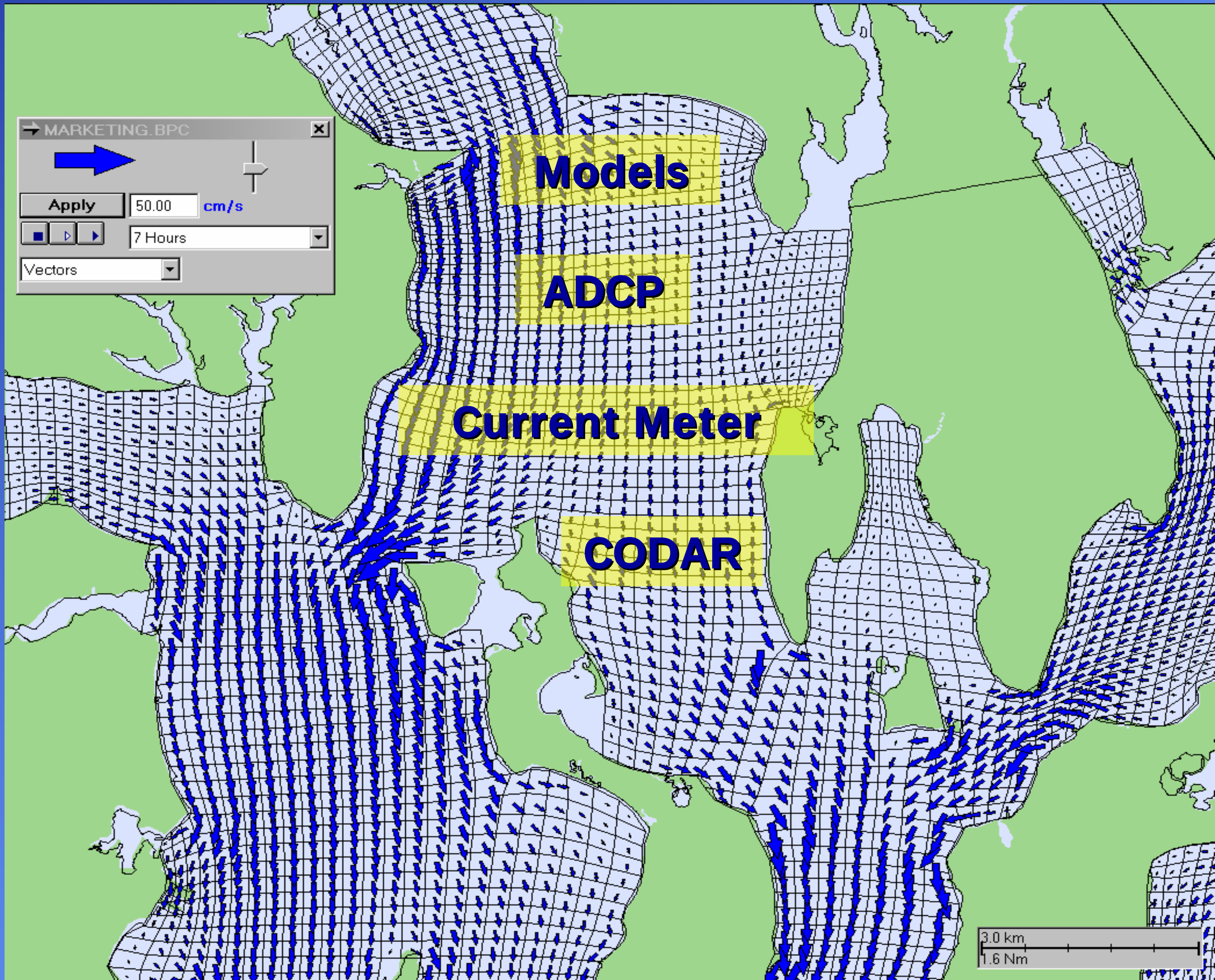

Environmental Data Requirements

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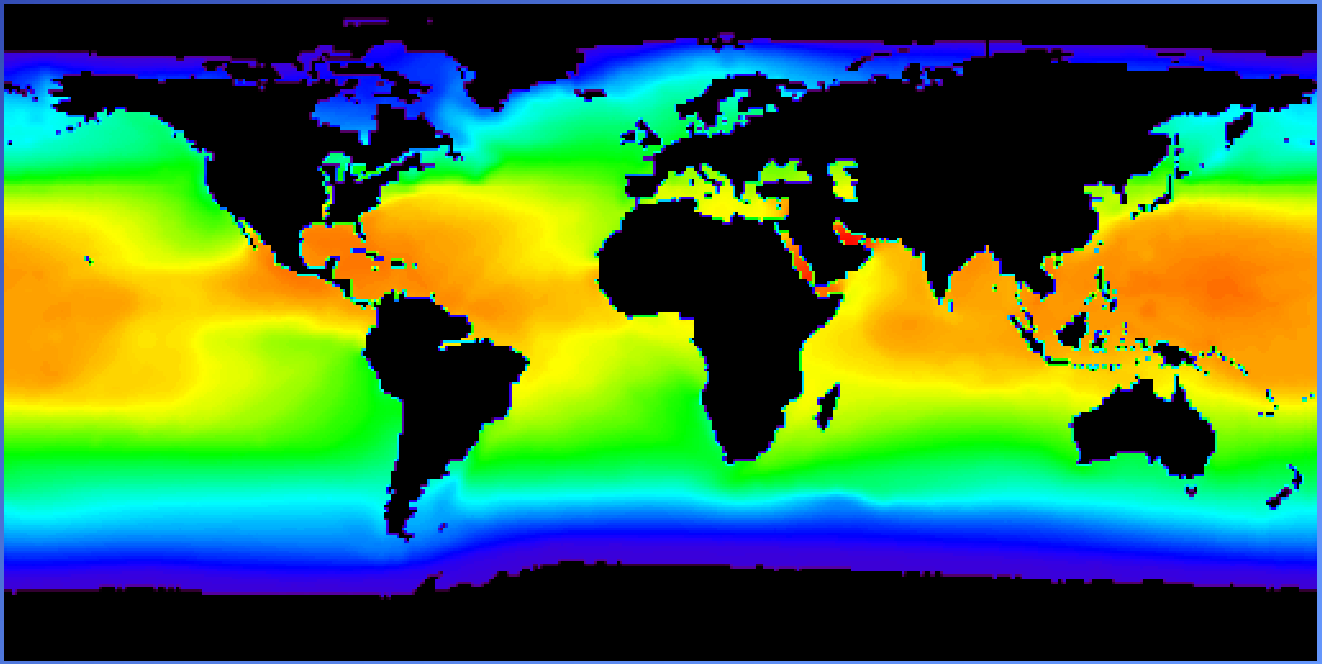

Environmental Data Requirements

- Land-Water delineation
- Bathymetry
- Currents
- Temperature
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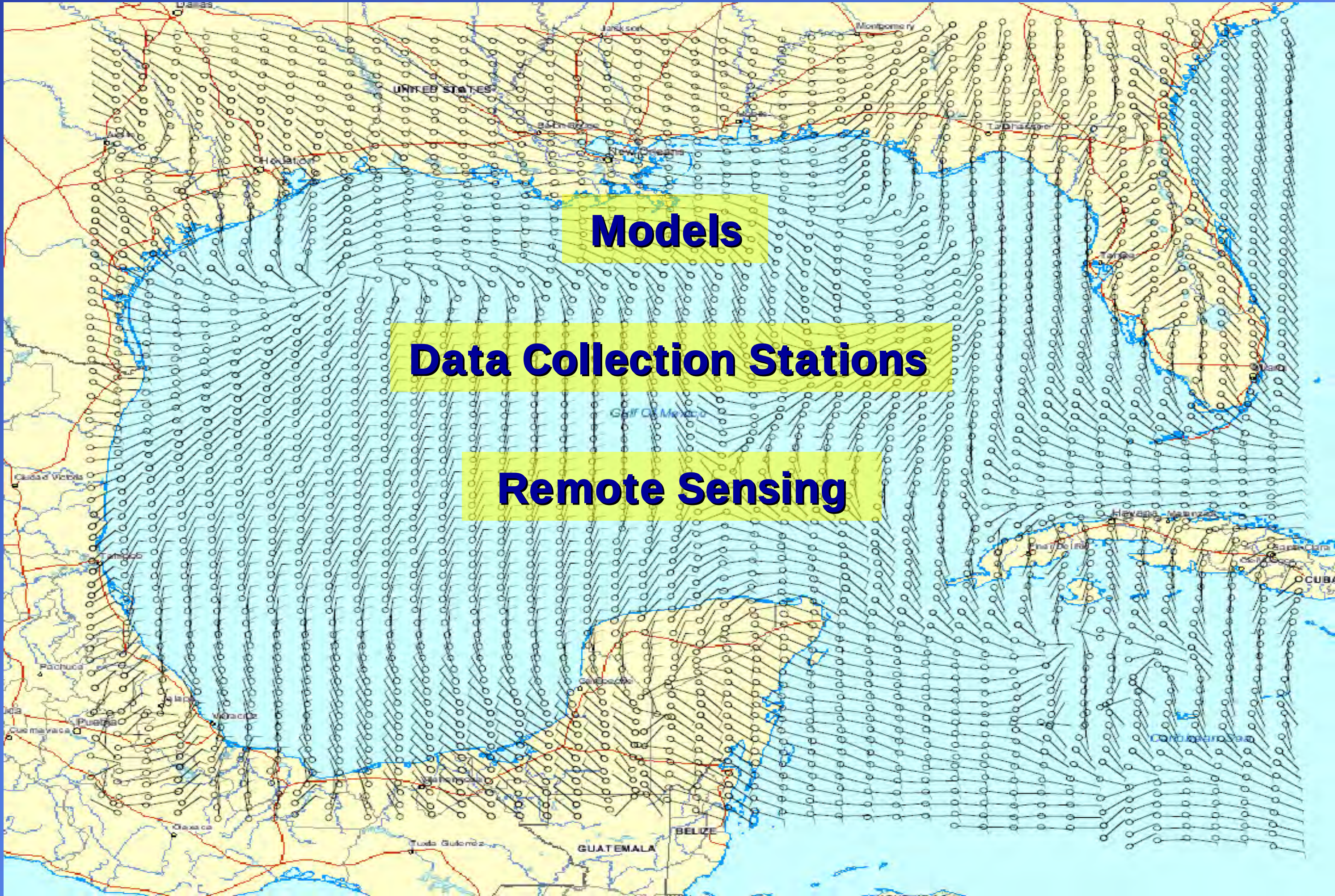
- **Winds**

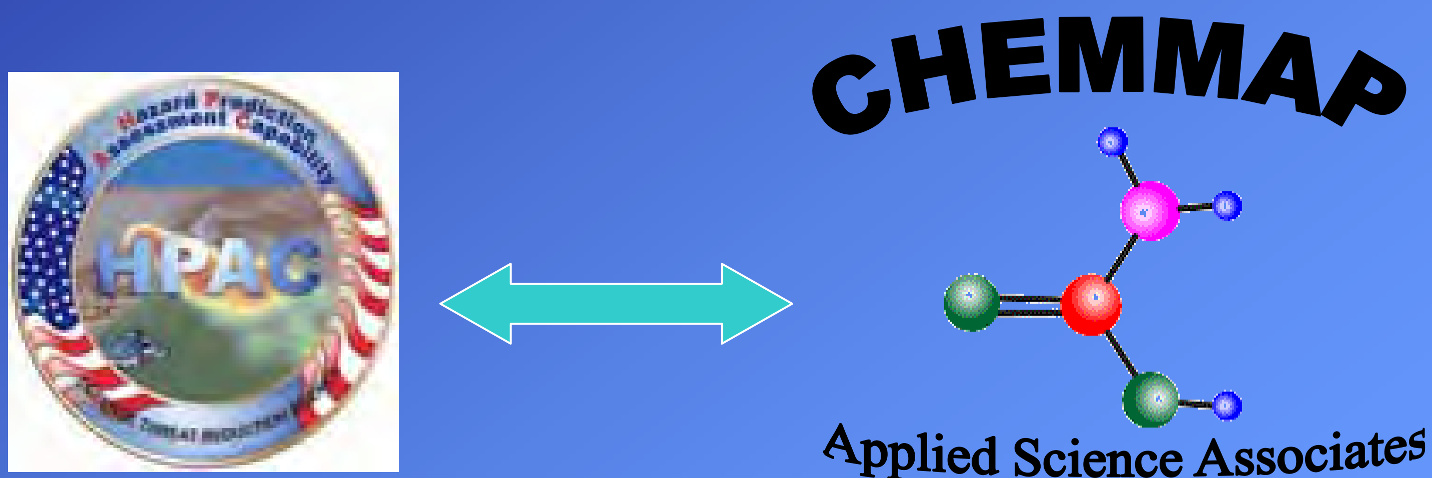


Data Availability

- A truly operational system requires rapid if not immediate availability of datasets ranging in scale from global to potentially 10's of meters
- Global scale datasets are readily available and local datasets are typically available within the Continental United States (CONUS). However, these datasets are not usually integrated.
- Outside CONUS regions mid and local scale datasets are often difficult to obtain
  - Intelligence Assets
  - Environmental Reconnaissance
  - Dedicated reach back cells

Phase I Objective

- Couple ASA's waterborne chemical transport and dispersion model with the HPAC system as a feasibility assessment for future complete integration



CHEMMAP

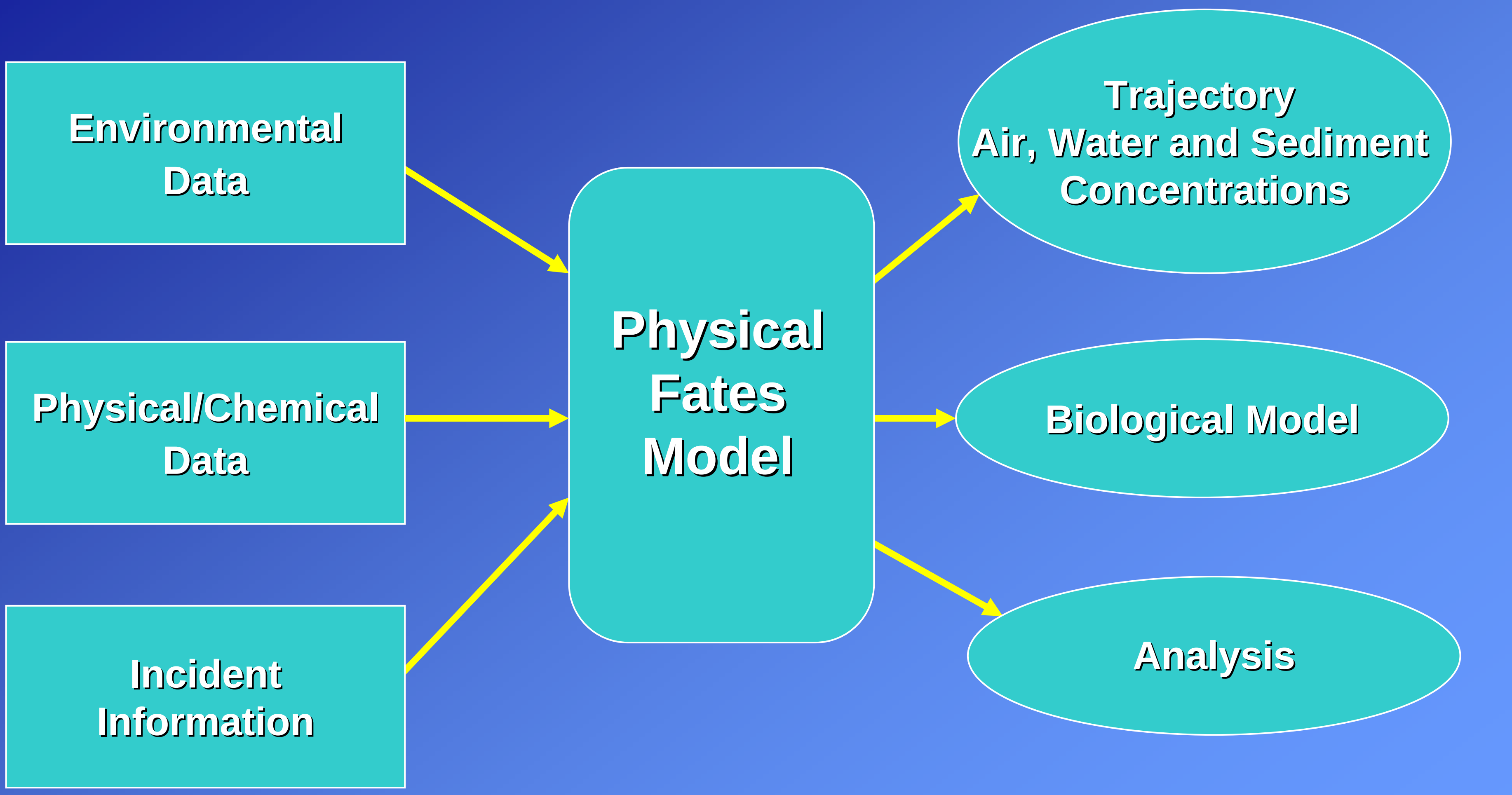
- Integrated modeling system designed to predict the trajectory, fate and effects of Toxic Industrial Chemicals and Materials

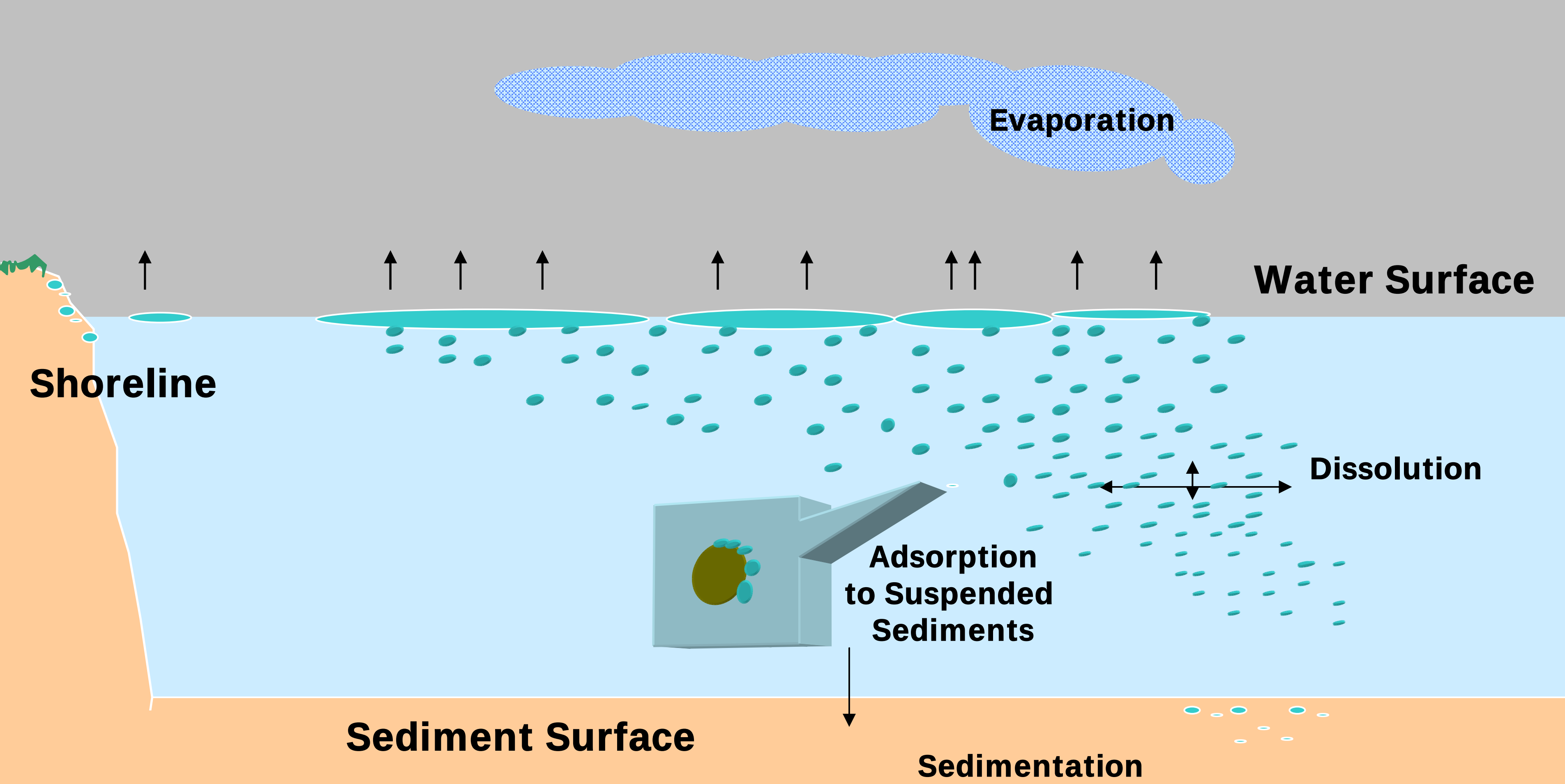
- Developed as a Natural Resource Damage Assessment Model for US Government Regulations

- Expanded commercial development
  - SIMAP (Oil Spill Impact Model Application Package)
  - CHEMMAP (Chemical Model Application Package)

- **Continued DoD development to predict transport and fate of weaponized chemical agents and refinement of TIC/TIM algorithms for military utility in waterborne environments**

CHEMMAP Structure





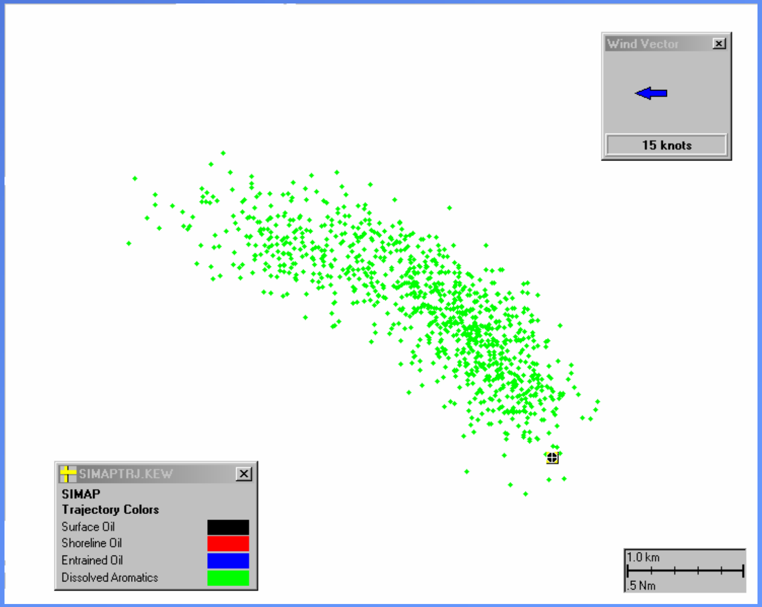
Physical / Chemical Processes

- Dispersion
- Spreading
- Entrainment
- Dissolution

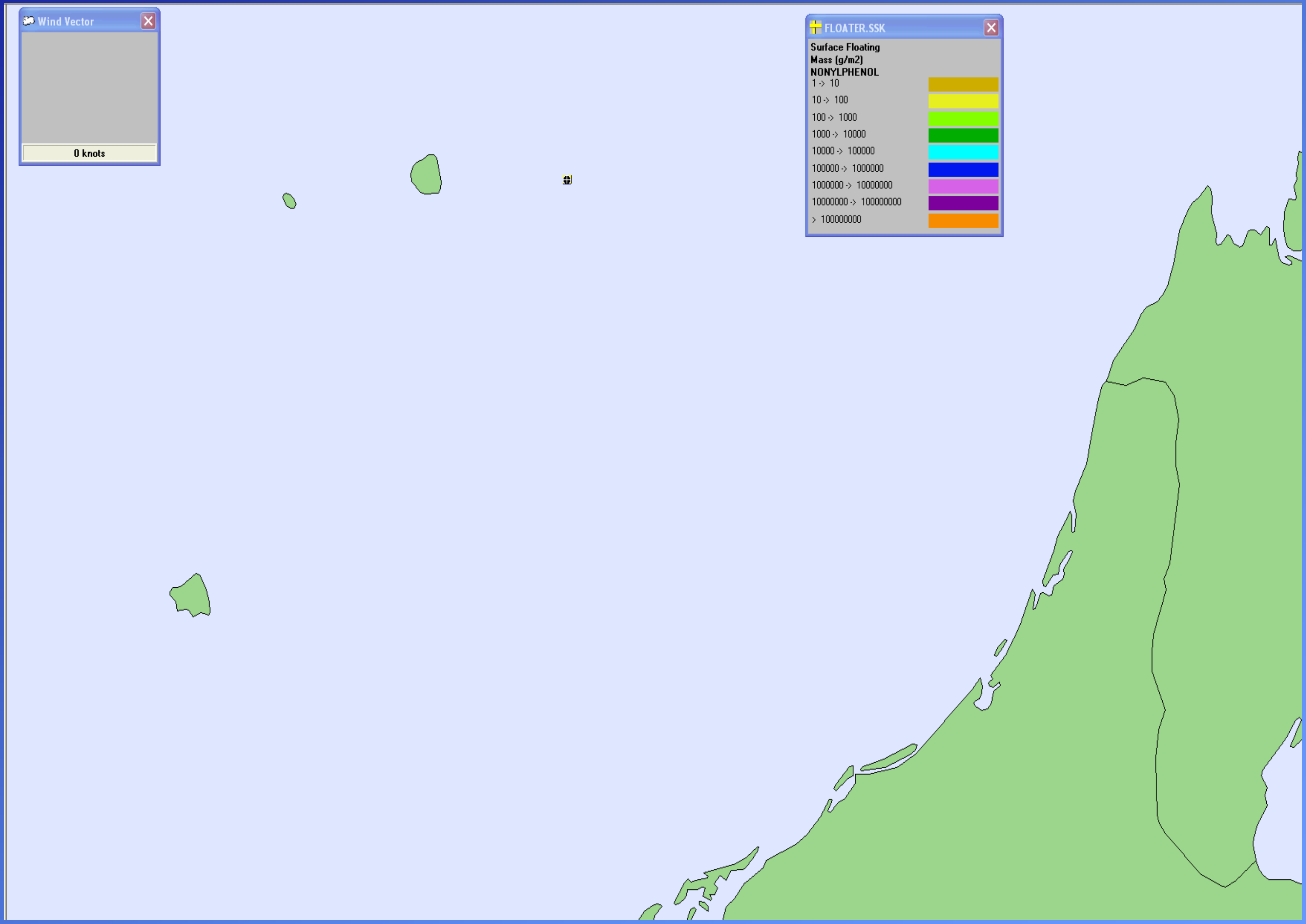
- Volatization
- Adsorption
- Settling
- Sediment Mixing
- Degradation

Modeling Approach

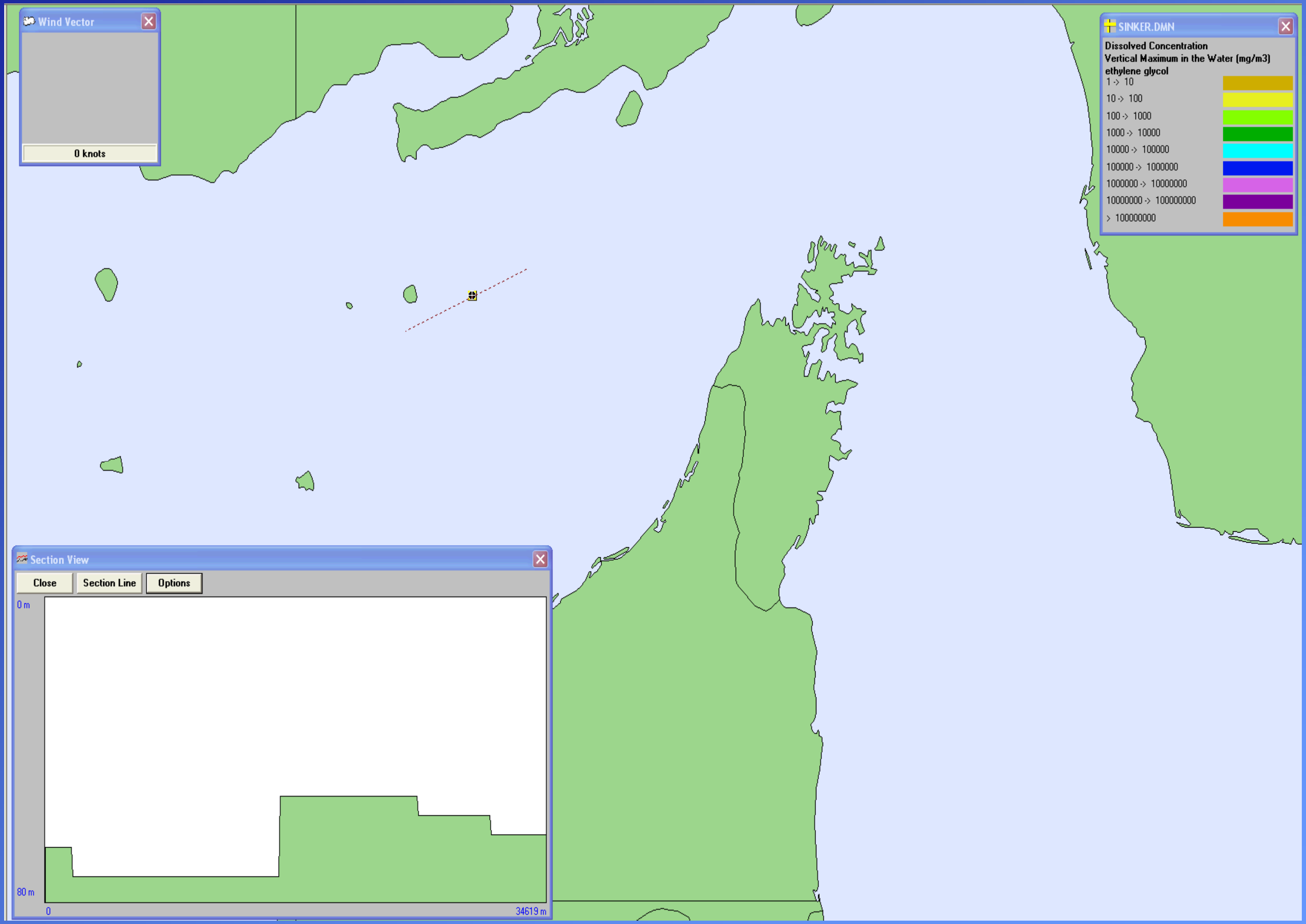
- Three-Dimensional Lagrangian Particle Model
- Each particle has an associated
  - mass (density)
  - size
  - age
- Particle classified by spill conditions and chemical properties
  - on the surface (slick)
  - particulate in the water column
  - dissolved in the water column
  - adsorbed to sediment in the water column
  - on bottom sediments
  - stranded on shoreline
- Particles transported by
  - Currents
  - Winds
  - Natural Dispersion
  - Stokes settling



Floater Example

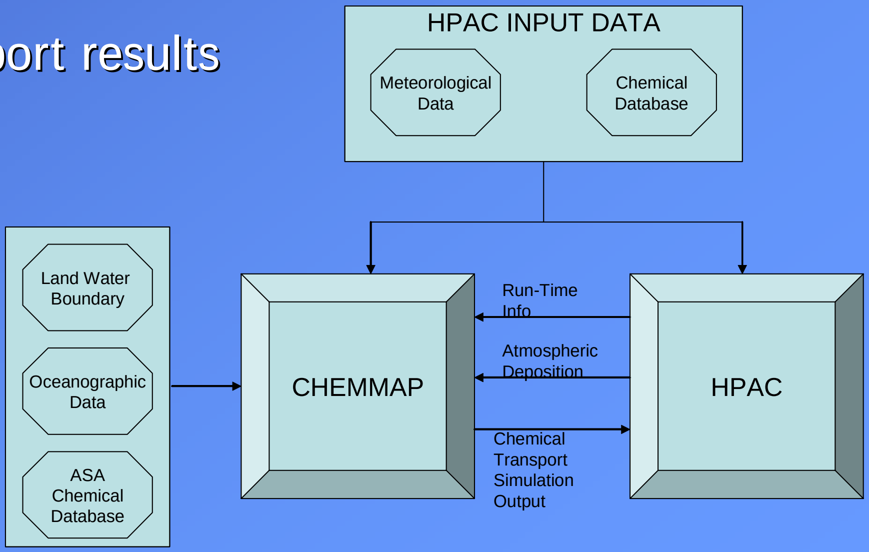


Dissolved Example

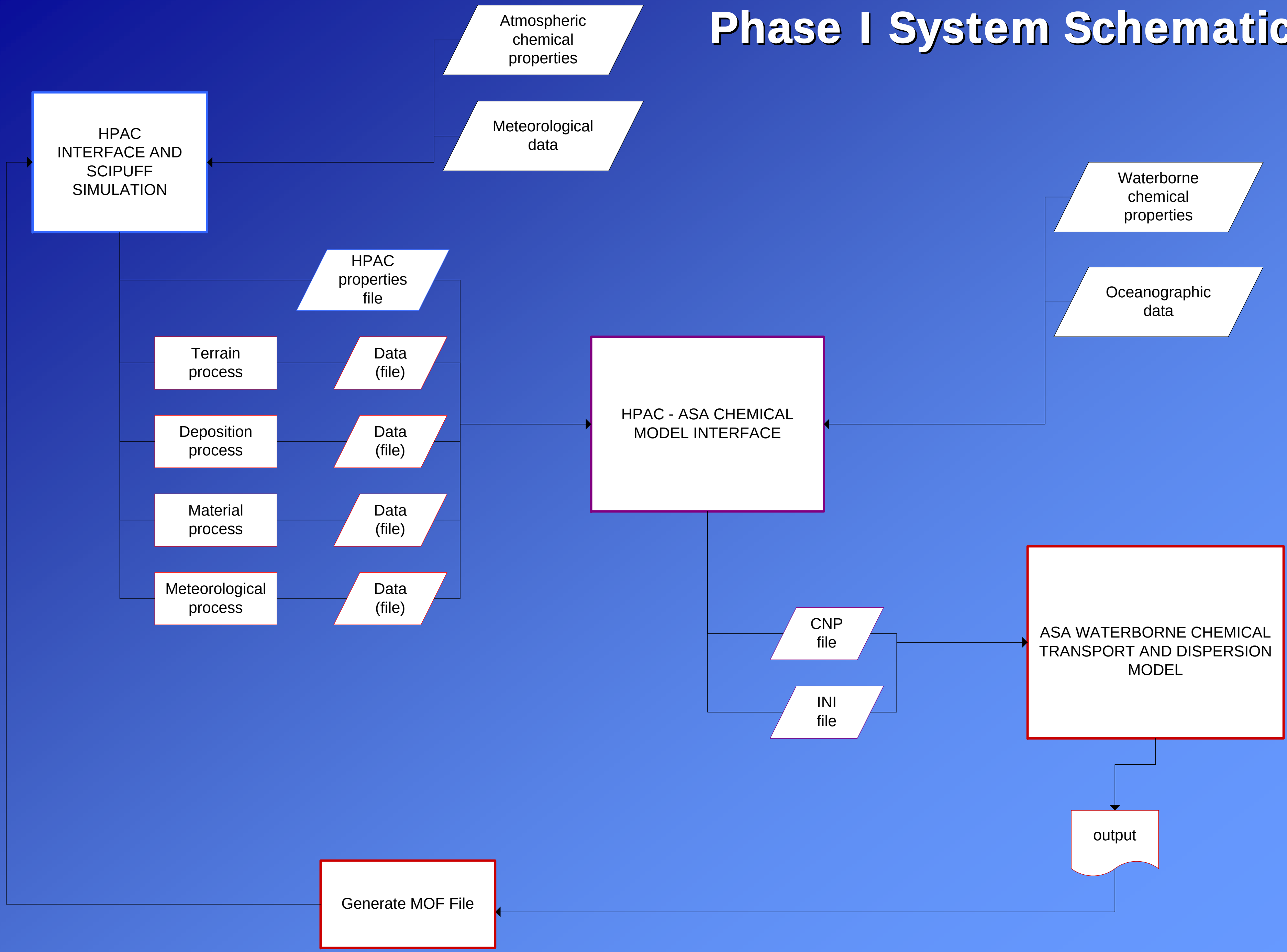


Phase I Integration

- Link HPAC meteorological files to ASA model
- Link HPAC chemical database to ASA model
- Link HPAC run-time files to ASA model
- Utilize HPAC terrain data to develop land-water grids
- Utilize SCIPUFF atmospheric deposition results as waterborne source
- HPAC readable waterborne chemical transport results



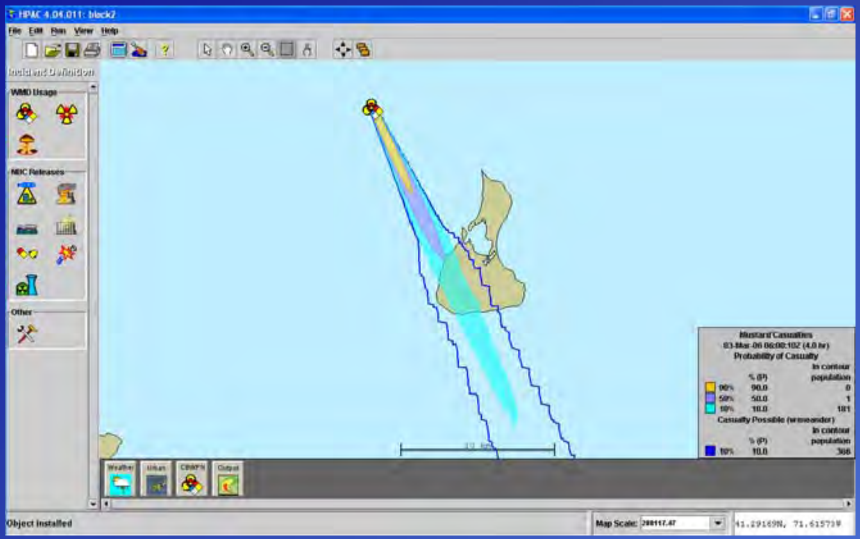
Phase I System Schematic



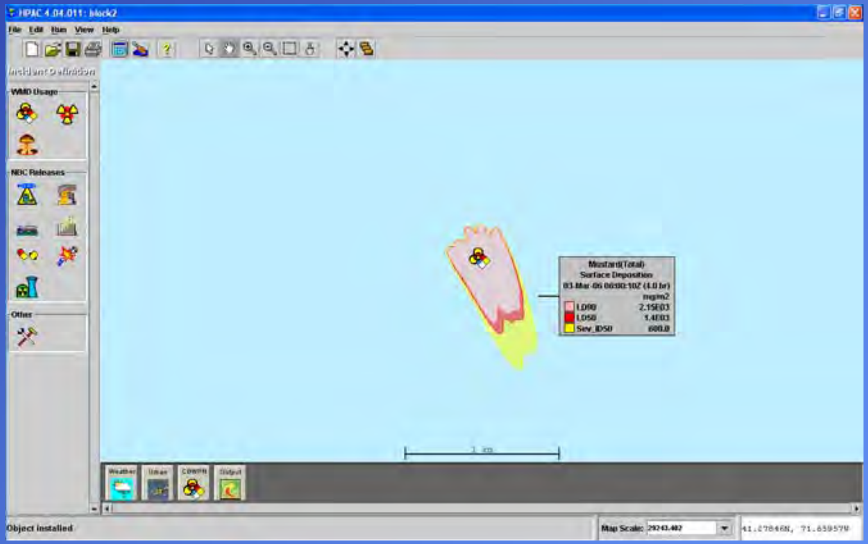
Interface

- Simplified wizard approach
- JAVA based interface and algorithms
- Consistent with HPAC development philosophy
  - Design patterns
  - Cross platform utilization
  - Re-using existing HPAC classes where possible

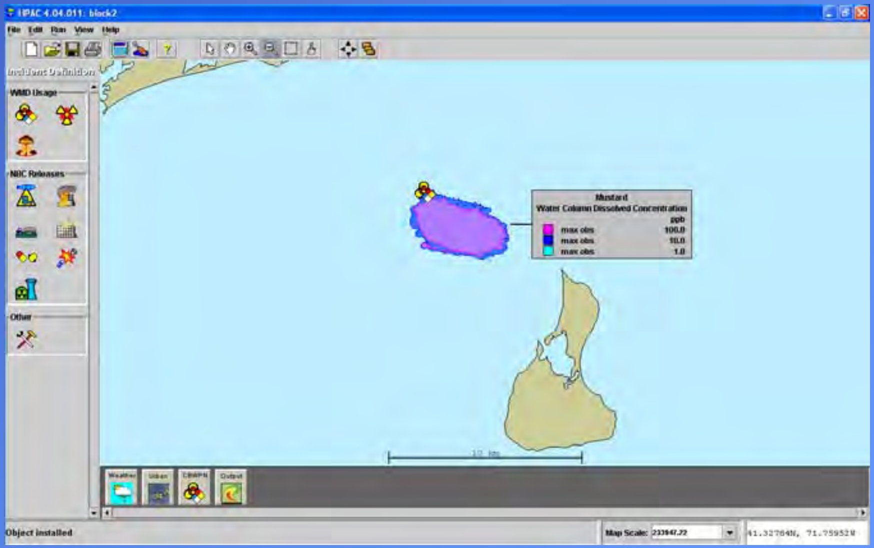
HPAC Atmospheric Results



HPAC Deposition Results



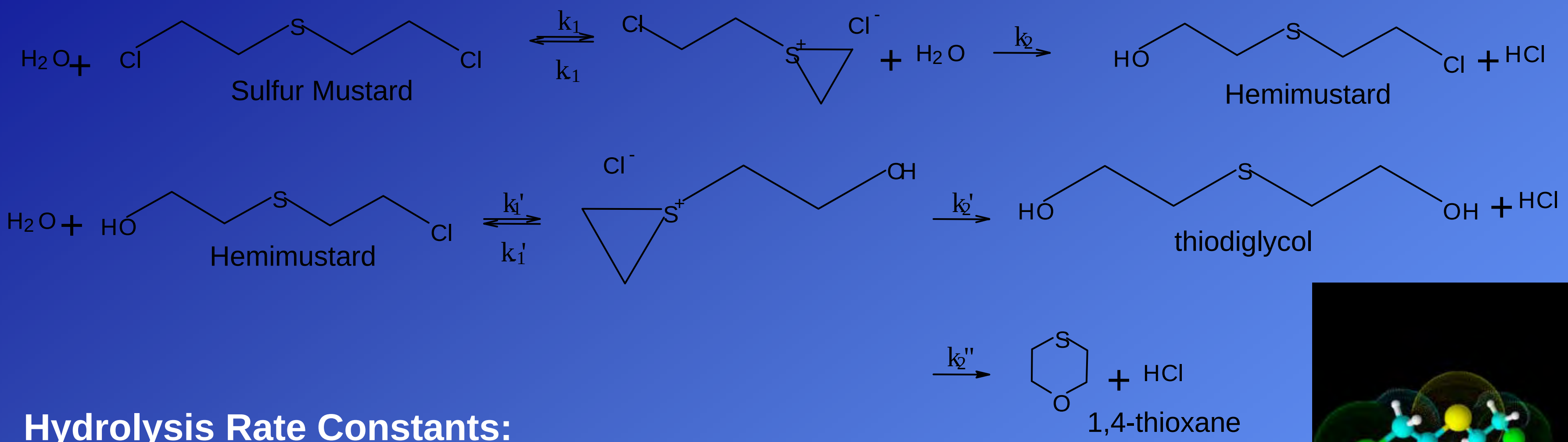
HPAC Waterborne Results

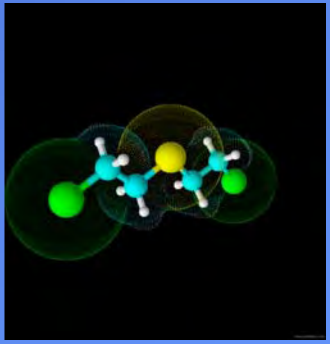


Phase II Objectives

- Investigate integration of model into JEM architecture
- Expand model's I/O architecture accommodate passing evaporated waterborne mass to SCIPUFF
- Develop analytical summary of traditional and thickened weaponized chemical agents fate and kinetics
  - Tabun
  - Sarin
  - Soman
  - Cyclosarin
  - VX
  - Distilled Sulfur Mustard
- Develop and incorporate numerical algorithms based upon analytical summary
- Develop expanded chemical agent database
- Develop advanced numerical algorithms to simplify operational user inputs
  - Adaptive time step
  - Adaptive gridding
  - Smart stochastic modeling

Mustard Kinetics





Hydrolysis Rate Constants:

Temperature	Fresh Water	Sea Water
(°C)	k_1 (min^{-1})	k_1 (min^{-1})
5	0.0124	0.0040
15	0.0390	0.0141
25	0.155	0.046

- In quiescent conditions, high concentrations of thiodiglycol result in the formation of stable sulfonium salts.
- These salts encase the remaining sulfur mustard preventing further dissolution and hydrolysis. If flow conditions remain low-energy, crusted mustard nodules can remain toxic for many years (<5).

QUESTIONS?

Chemical Agent Fate

Transport Models for Evaporating and Non-Evaporating Sessile Drops in Porous Substrates

By:

H. K. Navaz, B. Markicevic, A. Zand, Y. Sikorski, M. Sanders

Kettering University
Flint, Michigan

Chemical and Biological Information Systems
Austin, TX January 2007

Our Mission

➢ To create a system that can greatly enhance the ability to predict the outcome of a chemical attack event in terms of the existing level of an agent's concentration

Agent Fate Predictive Input (AFPI)

Averaged / Instantaneous

- Wind speed
  - ❖Turbulence
- Temperature
- RH
- Average agent droplet size and distribution
- Substrate type

Agent Fate Predictive System (AFPS)

Agent Fate Predictive Matrix (AFPM)

Agent Fate Predictive Tools (AFPT)

Agent Fate Predictive System (AFPS)

Agent Fate Predictive Input (AFPI)

Averaged / Instantaneous

- Wind speed
  - ❖ Turbulence
- Temperature
- RH
- Average agent droplet size and distribution
- Substrate type

Surface Evaporation Module

- Sessile drops
  - ✓ Non-permeable substrates
  - ✓ Small drops/large granules
  - ➢ Permeable substrates

Substrate Module

- Liquid transport
  - ✓ Porosity
  - ✓ Saturation permeability
  - ✓ Capillary pressure [*f(s)*]
  - ➢ Phase permeability [*g(s)*]
- Evaporation model
- Vapor transport
  - ➢ Effective diffusivity
- Chemical reaction
  - ❖ Rate and mechanism
- Agent/surface interaction
  - ❖ Rate and mechanism

Experimental Module

- Finding physical properties (viscosity, density, surface tension, etc.)
- Helping to find the transport properties
  - Porosity
  - capillary pressure
  - Saturation permeability
  - Relative permeability
  - Effective diffusivity
  - Adsorption rates
  - Activation energy
  - Etc..
- Model validation

AFPS

✓ Completed
➢ On-going
❖ Planned

Agent Fate Predictive Matrix (AFPM)

Agent Fate Predictive System

(AFPS)

Variables

- **Atmospheric**
  - Wind speed
  - Wind turbulence intensity
  - Temperature
  - Relative Humidity (RH)
- **Agent**
  - Type
  - Average drop size or size distribution
  - Average number of drops per unit surface area
- **Substrate**
  - Type
    - ❑ Chemical composition
    - ❑ Properties (porosity, Saturation permeability, relative permeability, capillary pressure, agent's effective diffusion coefficient)

Function (s) [Information Needed]

- The amount of agent present (Instantaneous/Averaged/Targeted time)

Limitations

- Thousands of experiments and/or simulations are needed to sufficiently create a good system
- Stiff set
- Maintenance
- Updating

Agent Fate Predictive Tools (AFPT) – On Going

Agent Fate Predictive Matrix

(AFPM)

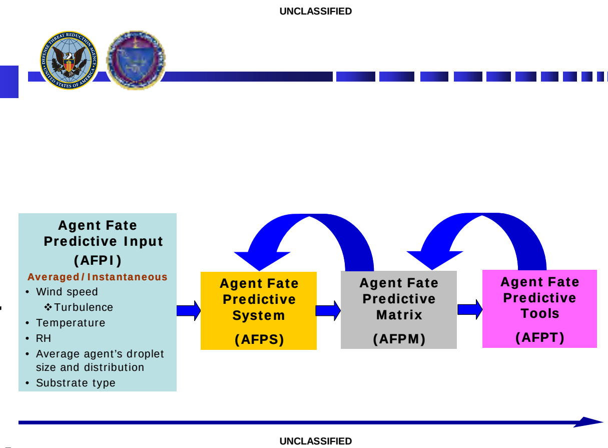
Limitations Overcome

- Thousands of experiments and/or simulations are needed to sufficiently create a good system
- Stiff set
- Maintenance
- Updating

Tools

- **Artificial Neural Network (ANN)** is a computer program that is capable of learning patterns or relationships via training examples (Taken from AFPM). It resembles biological neural nets in two ways:
  - ❖Knowledge is acquired by the network through a learning or training process
  - ❖Knowledge is stored via inter-neuron connection strengths (weights)
- Can asymptotically find the minimum number of required input from the AFPM
- Can be updated for new data (as they may become available), by a simple re-training process

Surface Evaporation Module



- Model developed
- Model validated with wind tunnel data
- Model validated with outdoor data
- Model and experiments showed that the percentage of mass left is a general function of temperature and non-dimensional time regardless of the drop size. Length scale: $\left(\frac{V}{r^2}\right)^{-1}$, Time scale: $tu^*\left(\frac{V}{r^2}\right)^{-1}$
- Model was used as a pilot methodology to verify the robustness of our overall approach (AFPI, AFPS, AFPM, and AFPT)

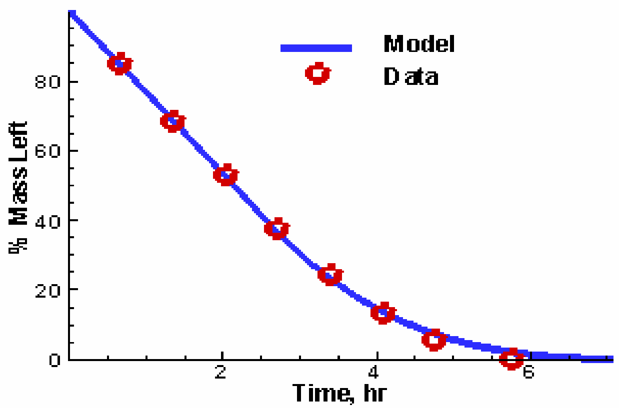
References:

Navaz, H. K., Chan, E., and N. Kehtarnavaz, "A Comprehensive Study of HD Sessile Droplet Evaporation on Impermeable, Non-Reacting Substrates," Presentation at the CBD November 2006, Hunt Valley, MD.,

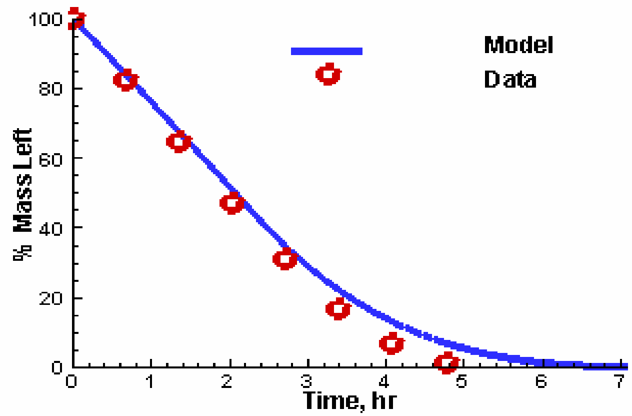
To be submitted to the *Journal of Hazardous Materials*.

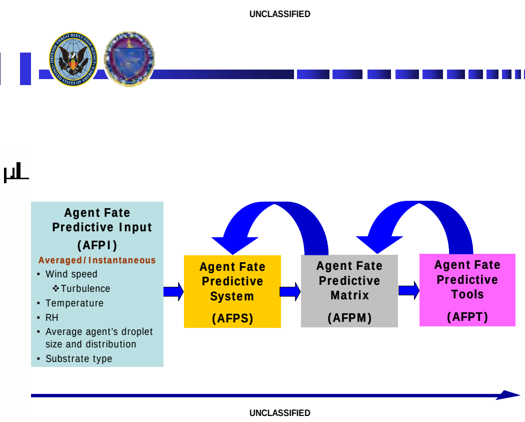
Model Development and Validation with Laboratory Data

HD on Glass, Wind Velocity = 3.66 m/s, Drop Size = 1 μL
Air Temperature = 15°C, m=1.200mg

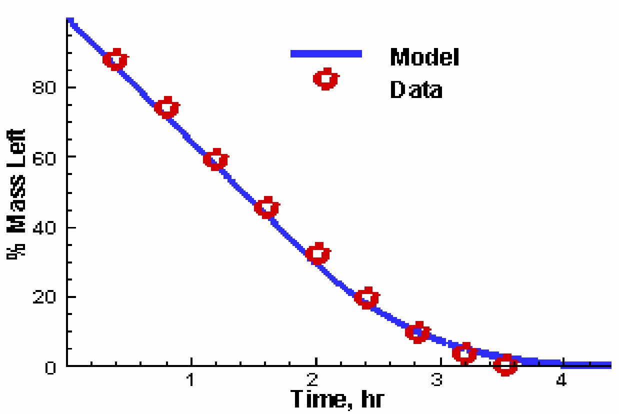


HD on Glass, Wind Velocity = 3.66 m/s, Drop Size = 1 μL
Air Temperature = 15°C, m=1.264 mg

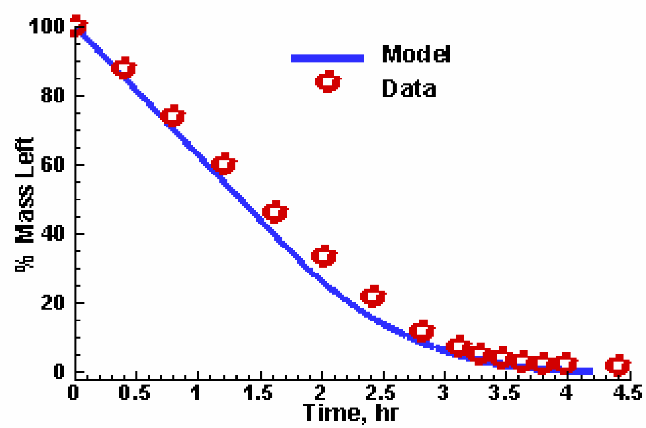




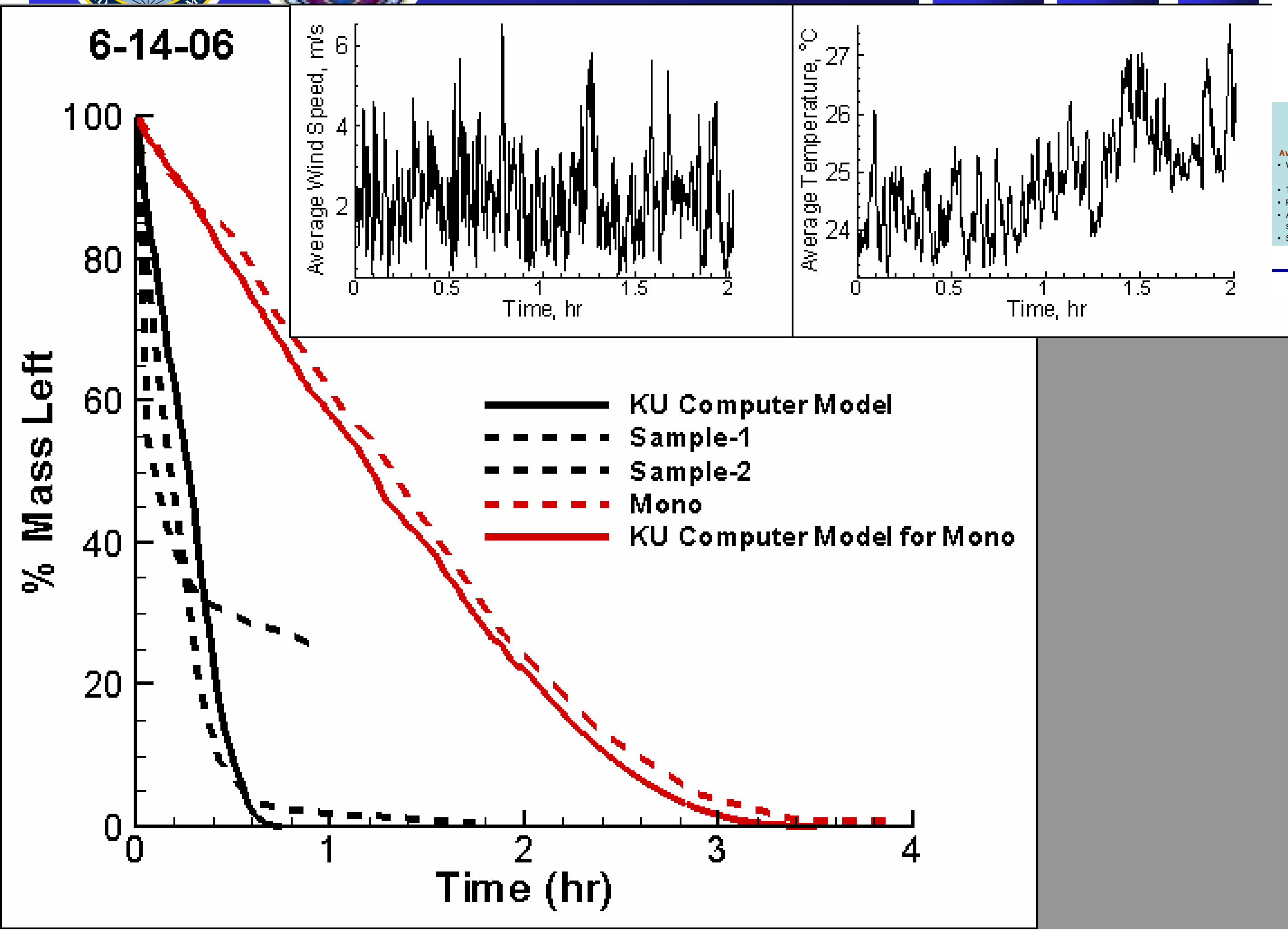
HD on Glass, Wind Velocity = 1.77 m/s, Drop Size = 6 μL
Air Temperature = 35°C, m=6.884 mg

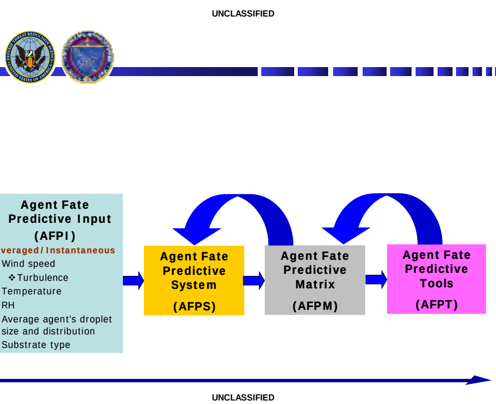


HD on Glass, Wind Velocity = 1.77 m/s, Drop Size = 6 μL
Air Temperature = 35°C, m=7.000mg

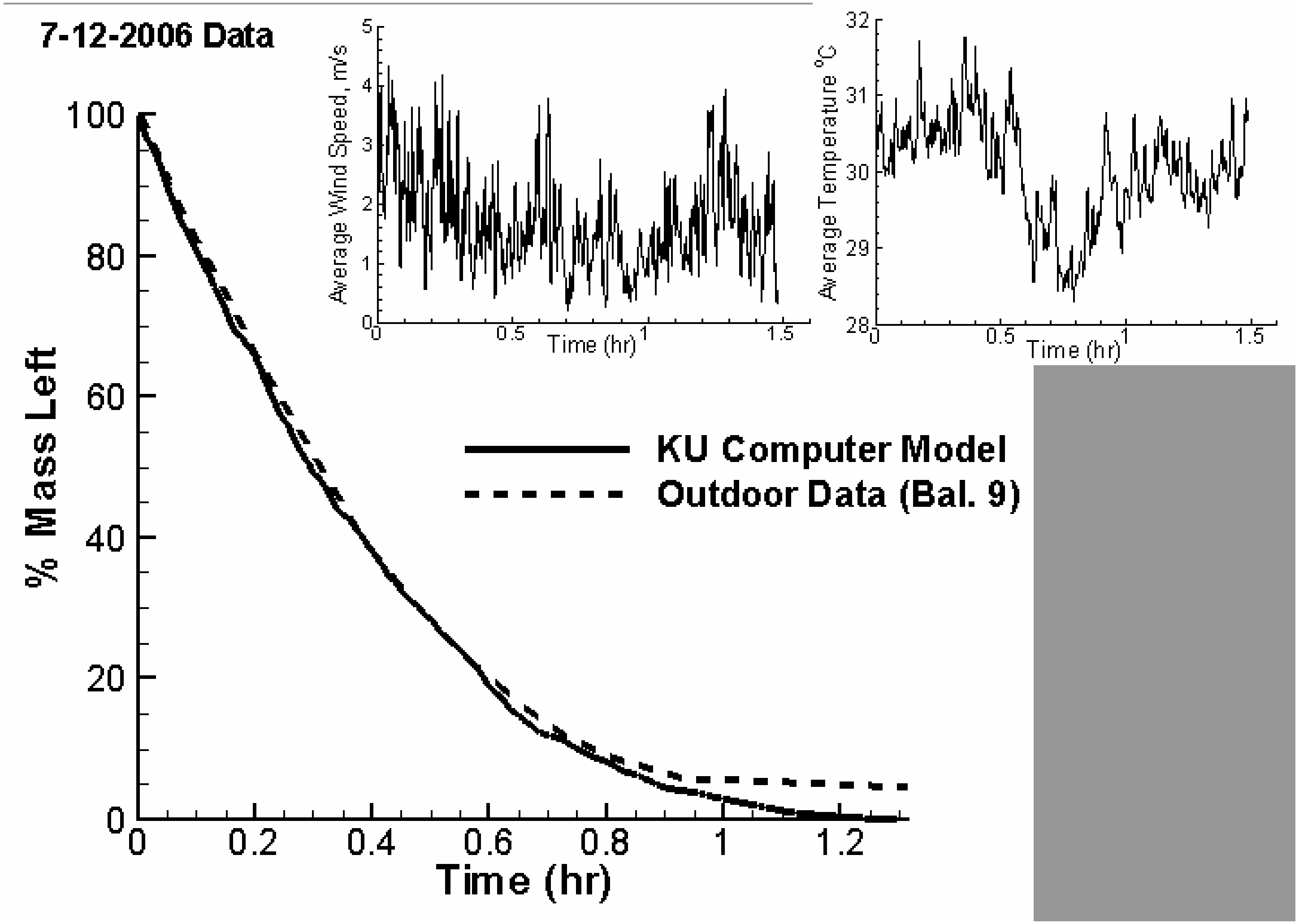


Model Validation with Outdoor Data 2006

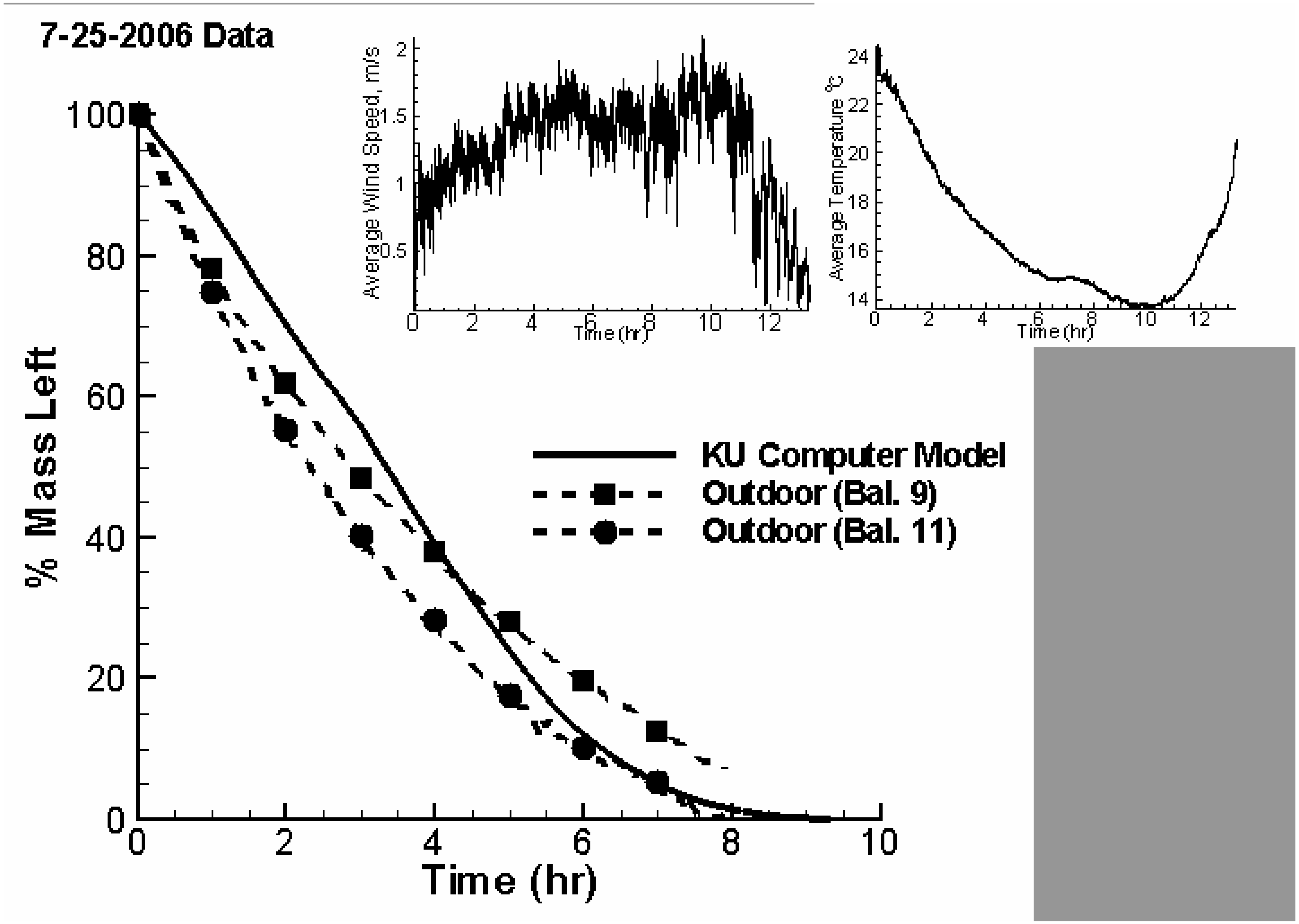




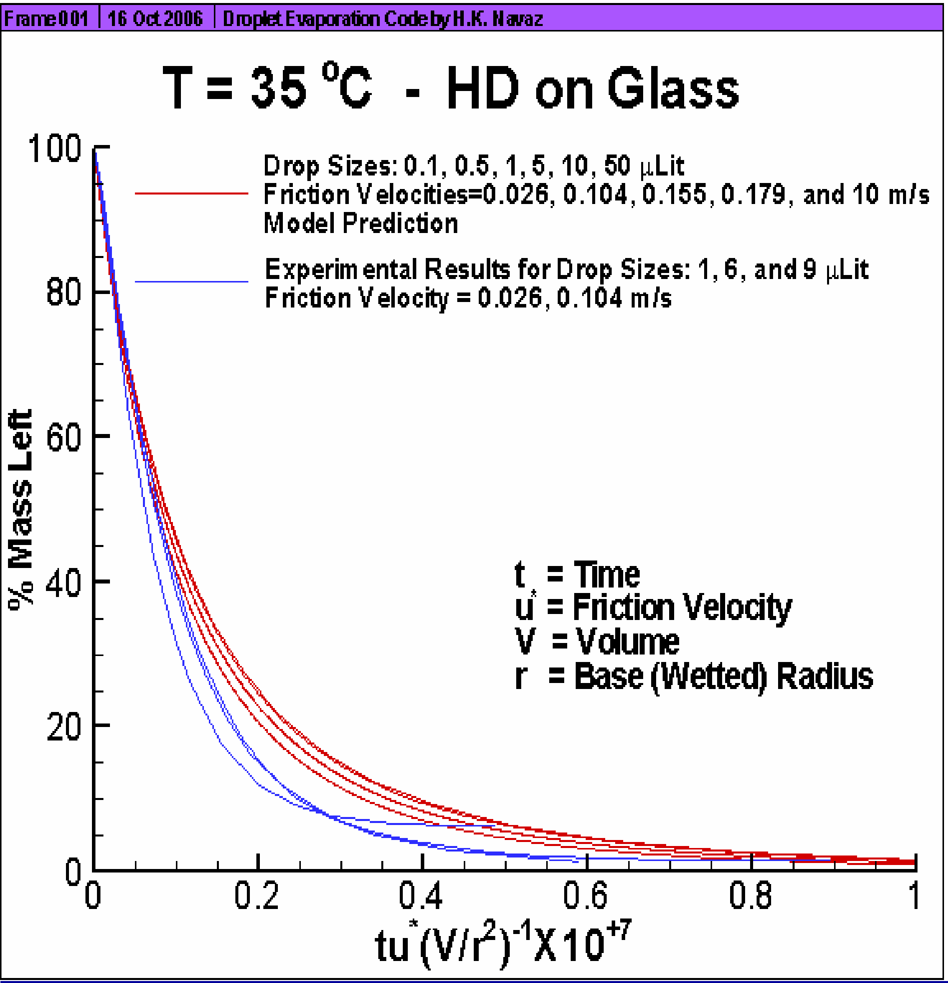
Model Validation with Outdoor Data - 2006

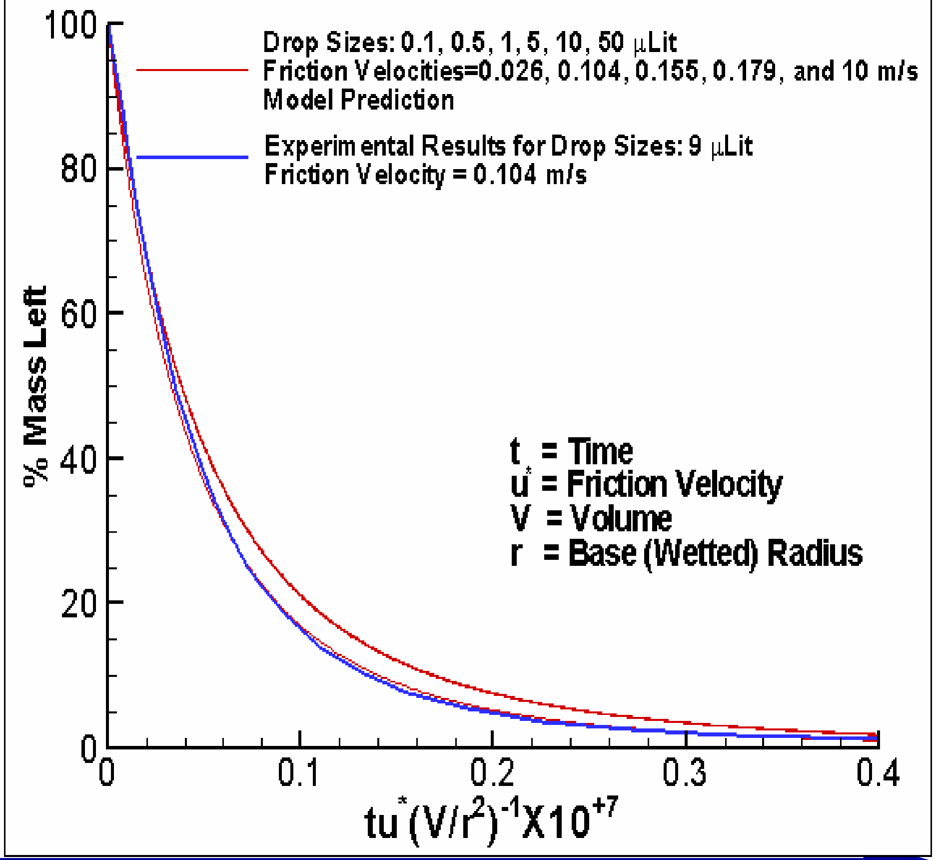


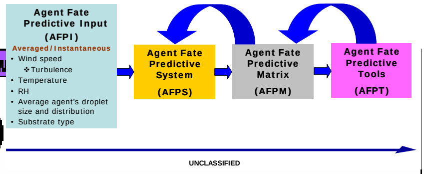
Model Validation with Outdoor Data - 2006



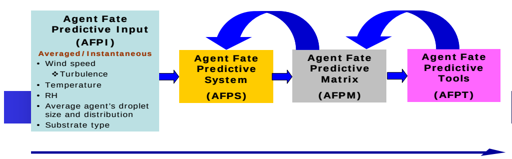
Evaporation Model Scalability







Conclusions



- Developed a robust system based on first principles and innovative methods for the Agent Fate Program
- Proved the robustness of the system by applying it to the evaporation of HD on glass
- Developed hybrid experimental and analytical methods to find the transport properties in a porous substrate
  - Capillary pressure
  - Relative permeability
- Addressed the scalability issue that assists us in developing the experimental methods
- Developed two analytical models for agent transport through a porous substrate

Acknowledgements

- The Air Force Research Laboratory, Human Effectiveness Directorate, Biosciences and Protection Division
- Wright-Patterson AFB, Ohio
- The US Army's Edgewood Chemical and Biological Center, Aberdeen Proving Ground
- Dr. James Savage
- Mr. William Kilpatrick
- Dr. Terrence D'Onofrio

DoD VV&A Documentation Tool (VDT)

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JPEO CBD SSA

(619) 553-2848

Jennifer.park@navy.mil

CBIS Conference Jan 2007

Agenda

- Background
  - Evaluating M&S
  - Role of VV&A
- Overview of the VV&A Documentation Tool (VDT)
- Benefits of the VDT
- Summary of the VDT

Introduction & Background

Complications with Using M&S

Scenario 1: Selecting Individual M&S

Stress Factors:

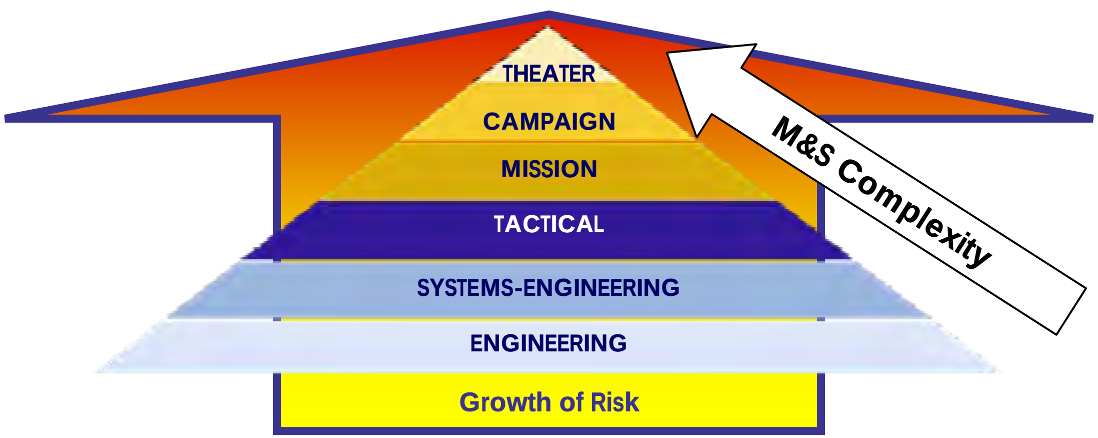
Finding the "best fit"
Compressed delivery schedule

Scenario 2: Reuse & Modularity

Stress Factors:

Assessment strategy for module compatibility
Limited understanding of the M&S modules

Scenario 3: System Complexity & Risk



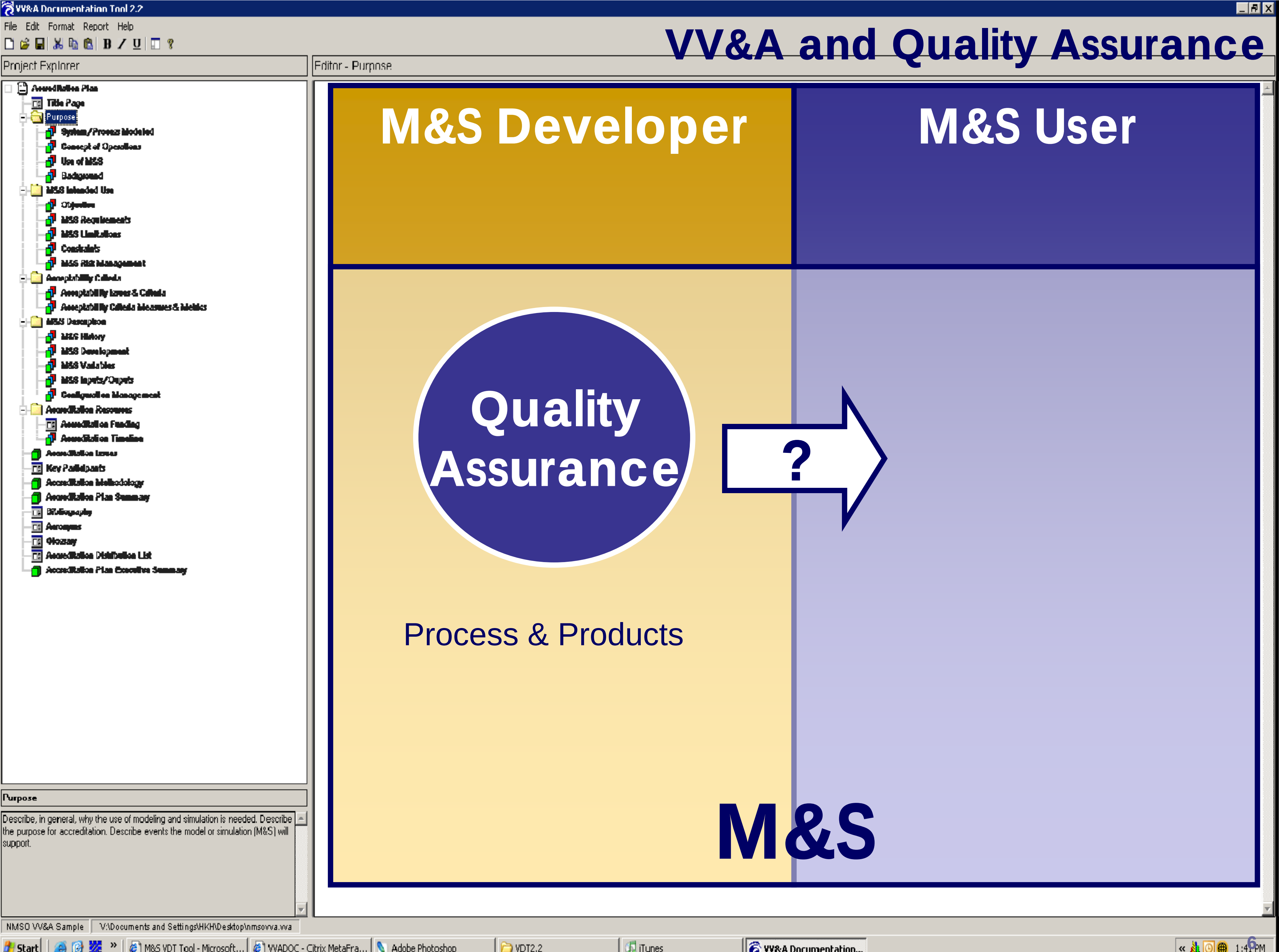
Stress Factors:

Risk rises with system complexity

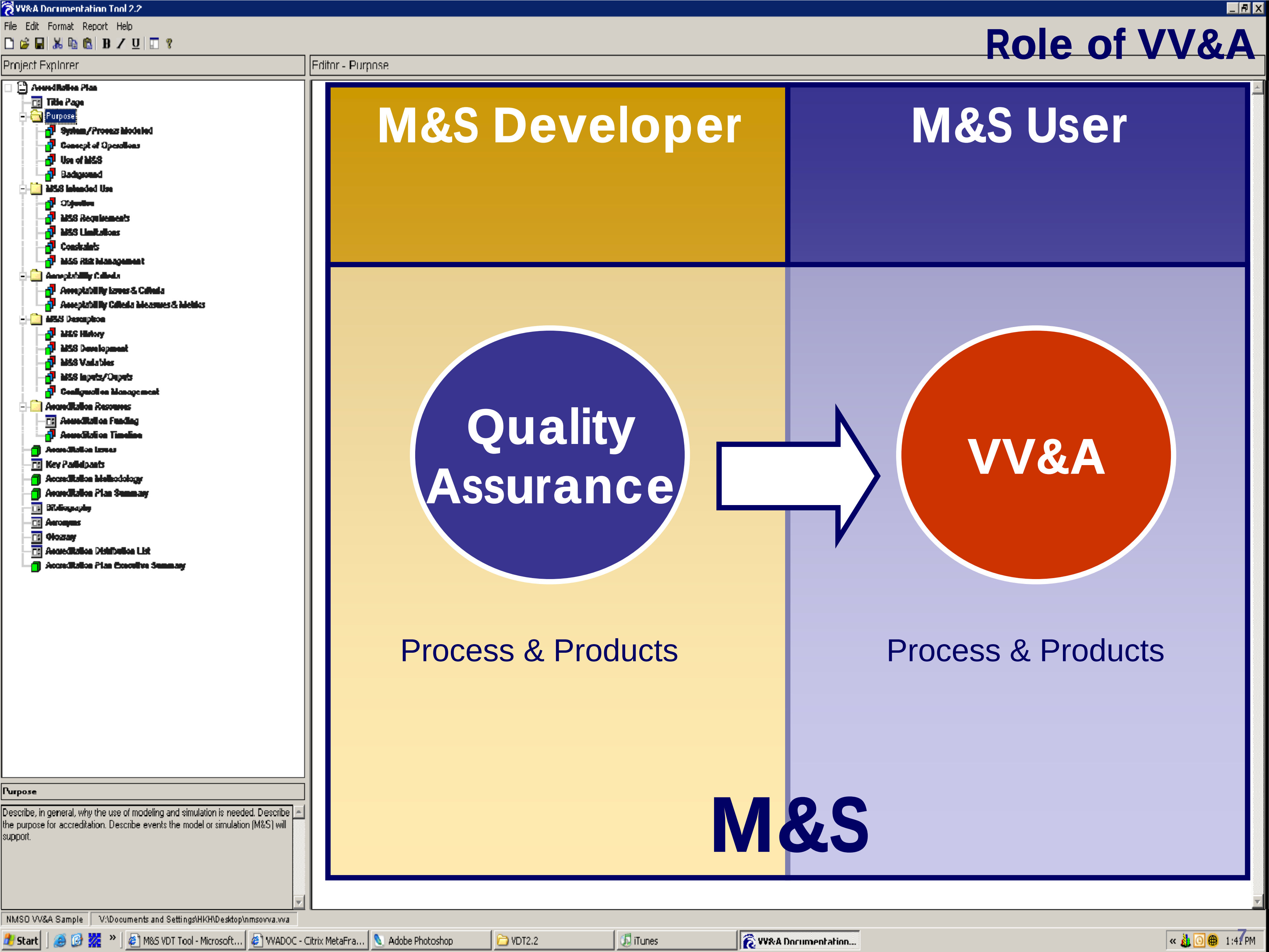
Assessment Strategy for M&S

- **1st Order (High): Capabilities/ Performance**
- **2nd Order (Middle): Systems Engineering/ Design**
- **3rd Order (Low): Implementation/ Testing**

VV&A and Quality Assurance



Role of VV&A


VV&A Documentation Tool 2.2
File Edit Format Report Help
Project Explorer
Editor - Purpose
M&S Developer
M&S User
Quality Assurance
VV&A
Process & Products
Process & Products
M&S
Purpose
Describe, in general, why the use of modeling and simulation is needed. Describe the purpose for accreditation. Describe events the model or simulation (M&S) will support.
NMSO VV&A Sample
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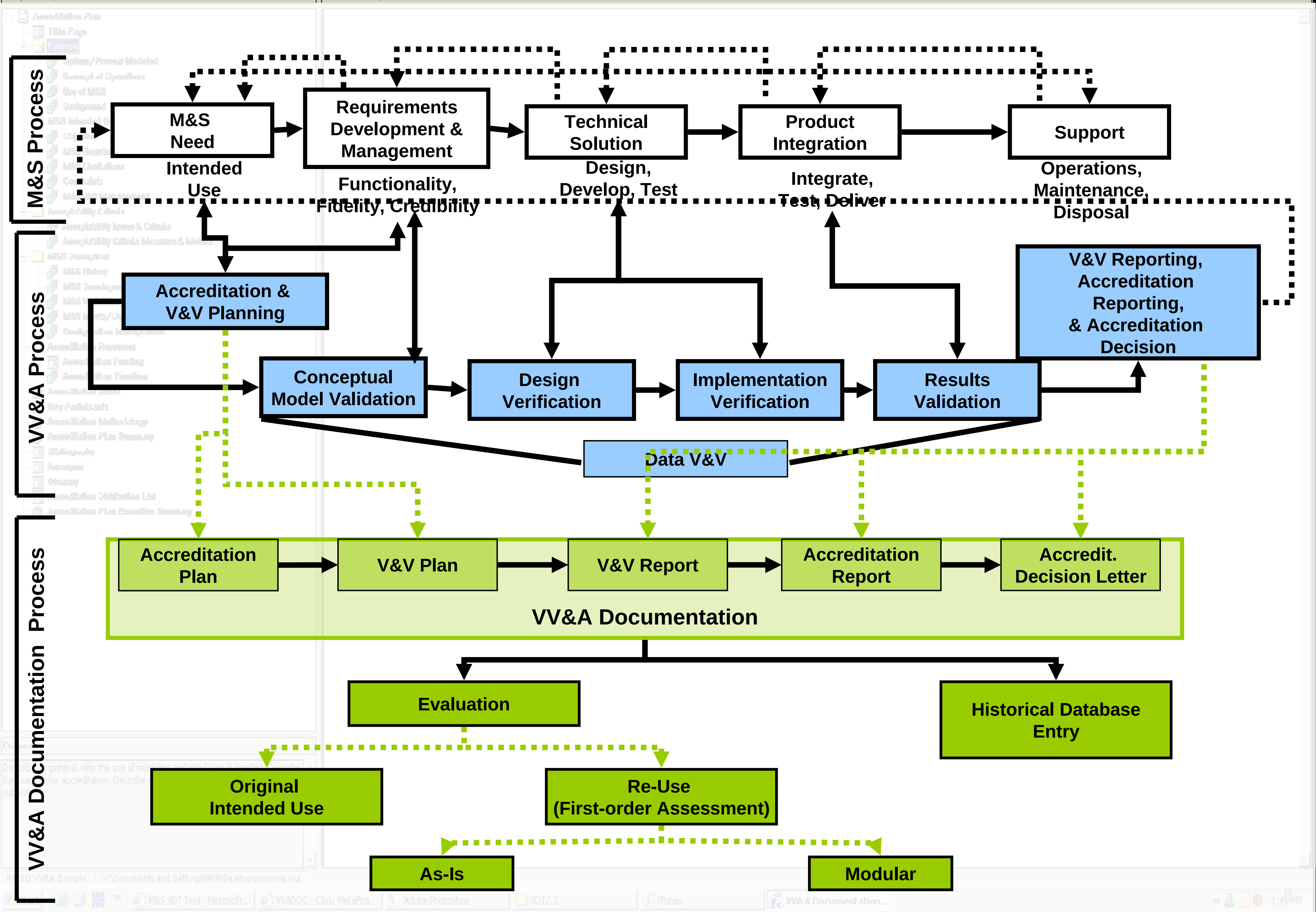
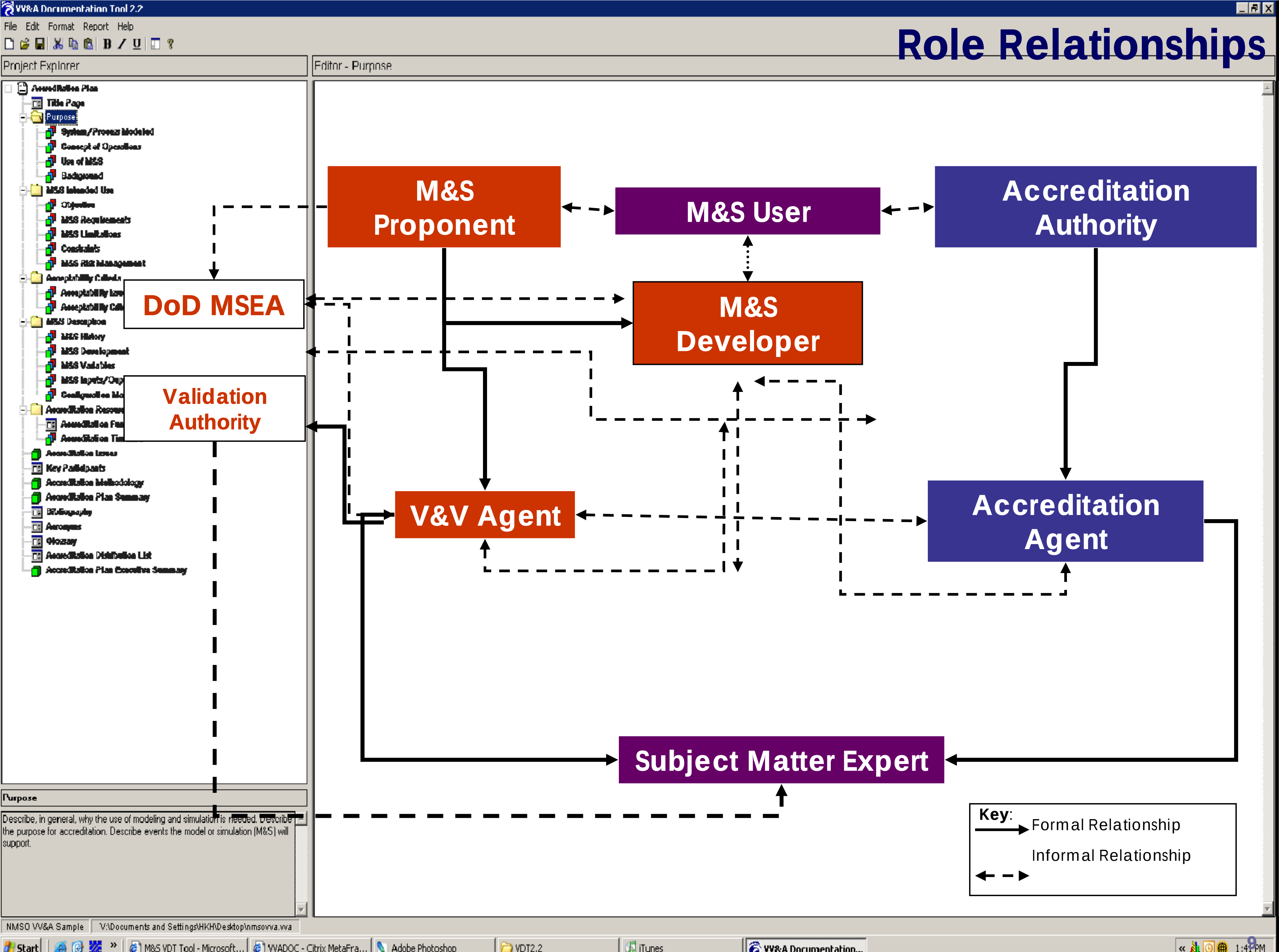
VV&A 101

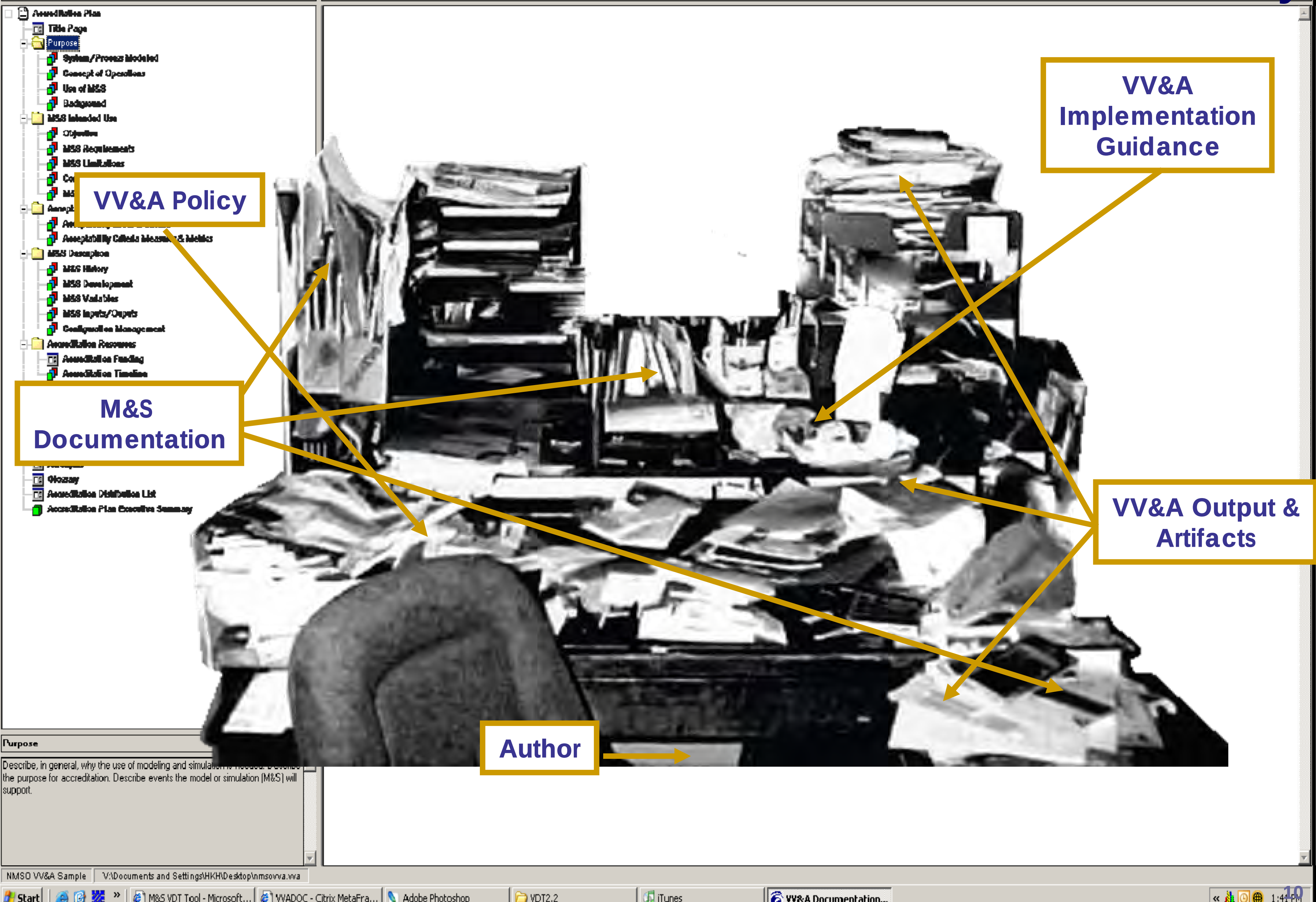


M&S Process
VV&A Process
VV&A Documentation Process
M&S Need
Intended Use
Requirements Development & Management
Functionality, Fidelity, Credibility
Technical Solution
Design, Develop, Test
Product Integration
Integrate, Test, Deliver
Support
Operations, Maintenance, Disposal
Accreditation & V&V Planning
Conceptual Model Validation
Design Verification
Implementation Verification
Results Validation
V&V Reporting, Accreditation Reporting, & Accreditation Decision
Data V&V
Accreditation Plan
V&V Plan
V&V Report
Accreditation Report
Accredit. Decision Letter
VV&A Documentation
Evaluation
Historical Database Entry
Original Intended Use
Re-Use (First-order Assessment)
As-Is
Modular

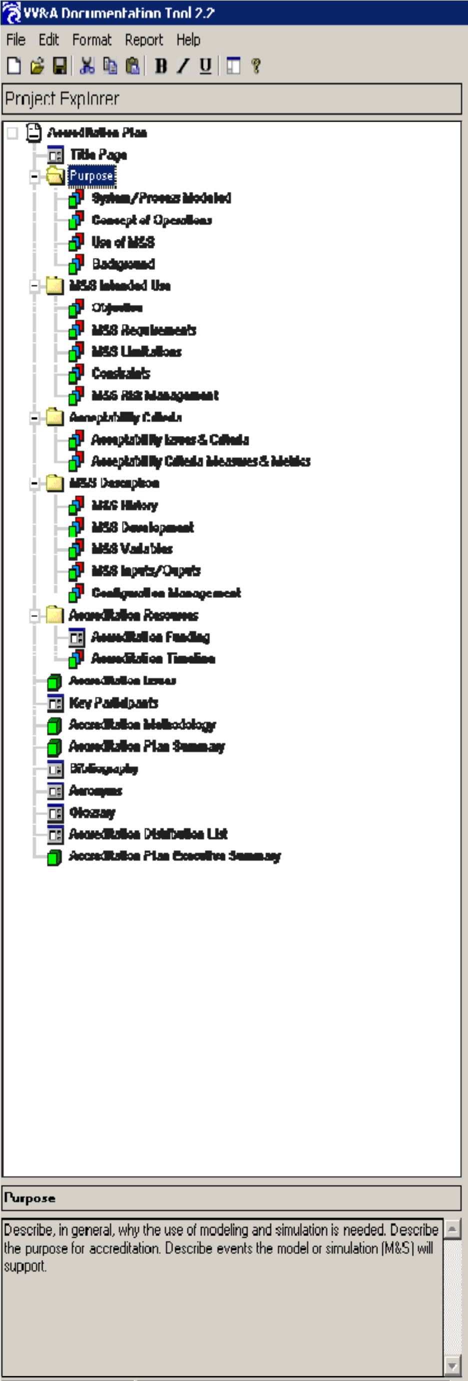
Role Relationships



The VV&A Doc Process Today



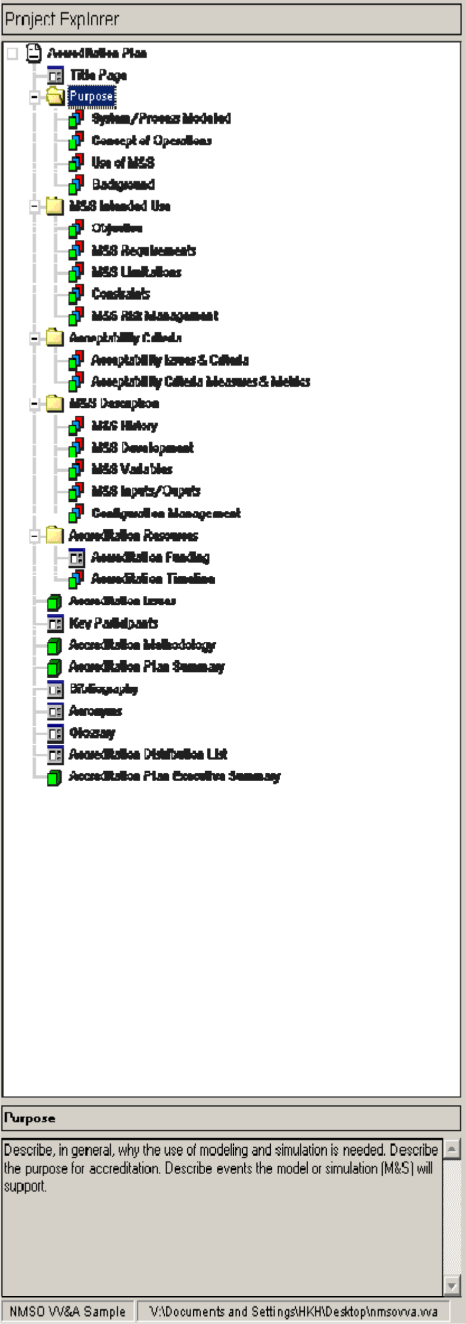
Background for VDT Development



The DoD needed a way to:

- Ensure compliance with policy and guidance
- Guide users through the VV&A process
- Ensure all VV&A documentation is accurate and consistent
- Expedite the VV&A documentation process for implementers through automation
- Standardize VV&A documentation

Goal



Streamline:
Standardize the Process by Using Automated Tools

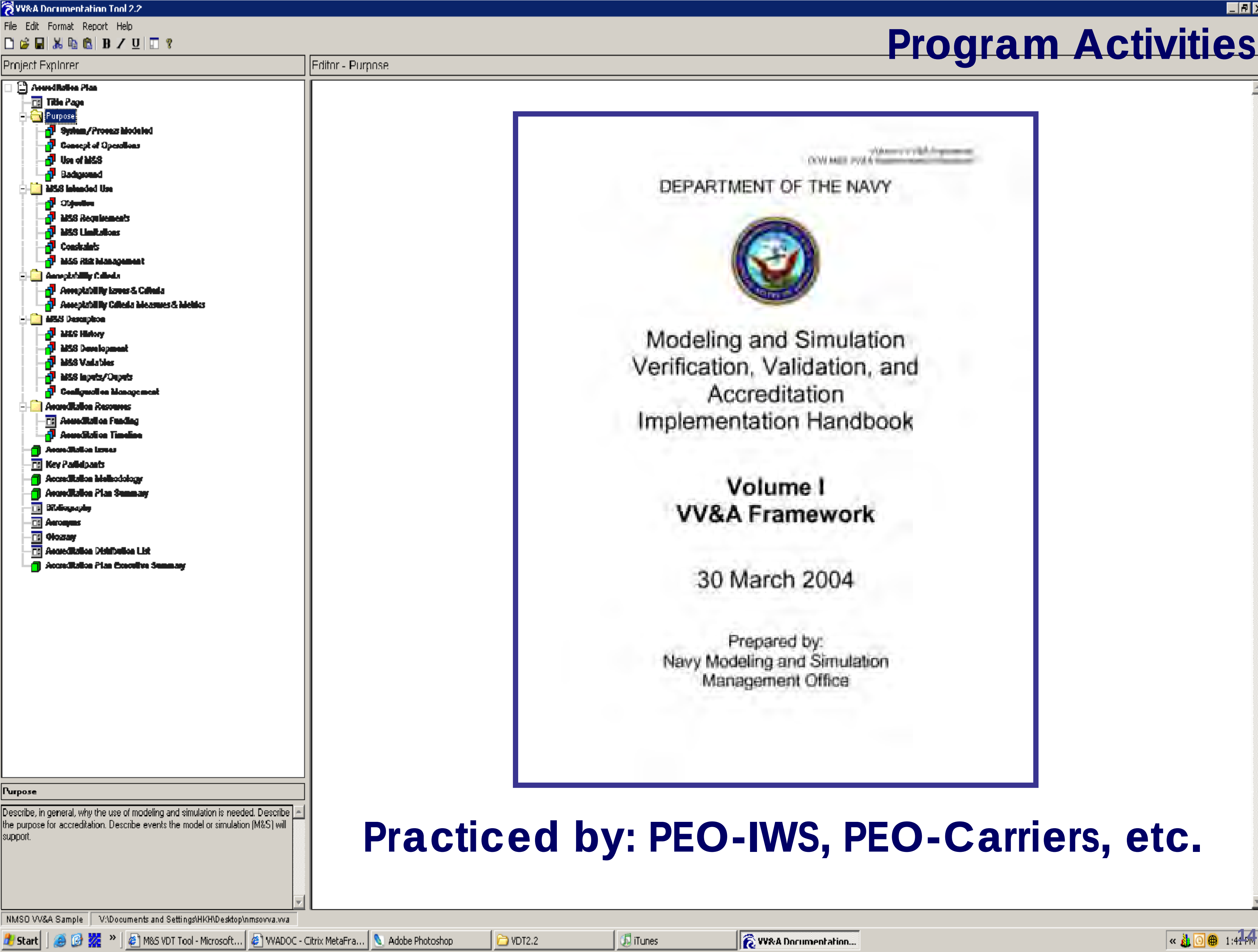
Pre-Requisites:
A standardized mechanism and infrastructure for the evaluation of M&S credibility

Solution:
Standardize VV&A Documentation

Standards Influences

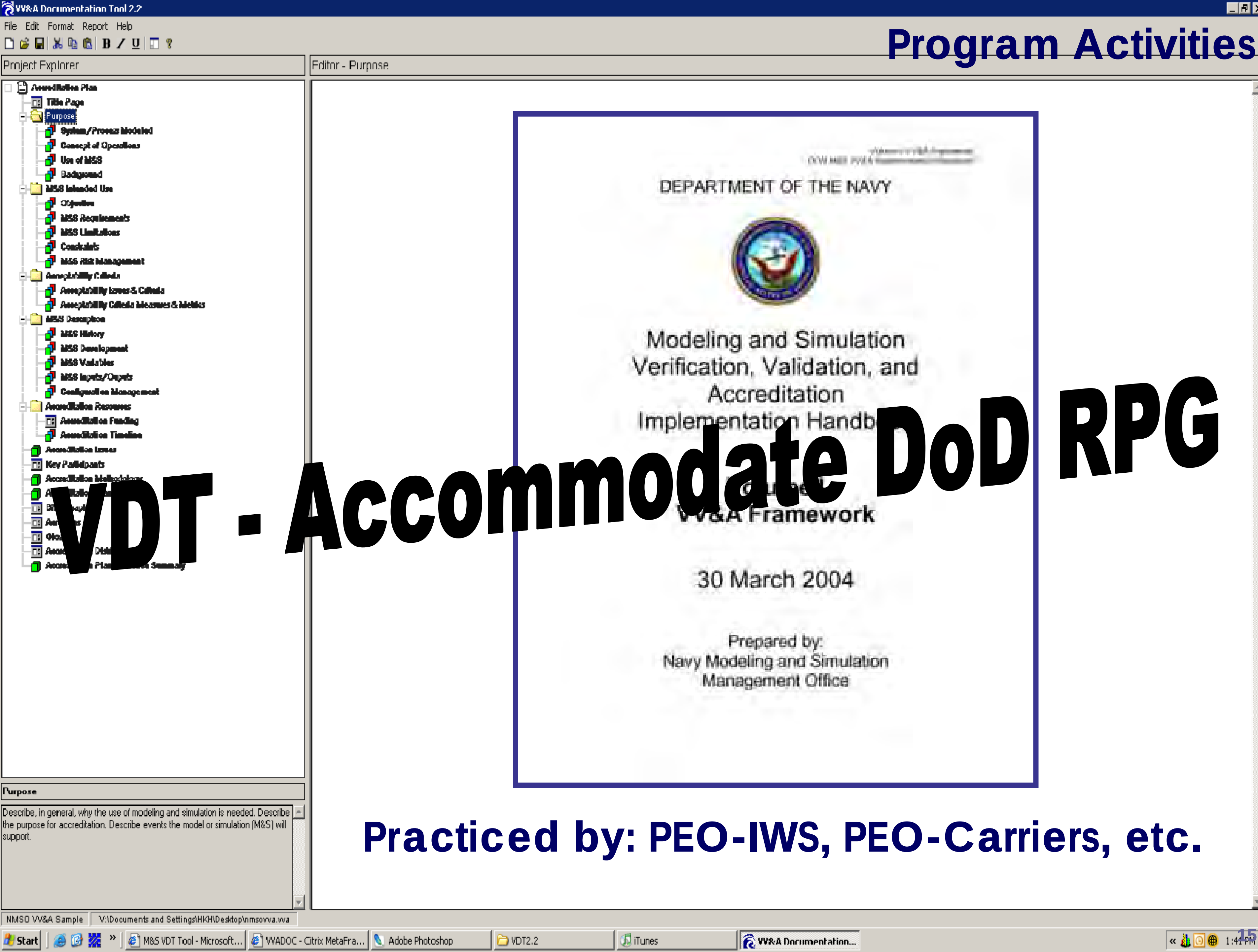
- DoD and Military Standards
- CMMI
- Commercial and International Standards
  - IEEE
  - ISO
- Engineering
  - Requirements
  - Software and Hardware
  - Systems
- Software V&V
- Programs with Successful VV&A

Program Activities



Practiced by: PEO-IWS, PEO-Carriers, etc.

Program Activities



VDT - Accommodate DoD RPG

Practiced by: PEO-IWS, PEO-Carriers, etc.

Vision for Standardized VV&A Docs

VV&A Documentation Tool 2.2

File Edit Format Report Help

Project Explorer

Editor - Purpose

Accreditation Plan
Title Page
Purpose
System/Process Modeled

DRAFT

DEPARTMENT OF THE NAVY

Standard Templates for VV&A Documentation

28AUG2005

Prepared by:
Navy Modeling and Simulation Office

TABLE OF CONTENTS

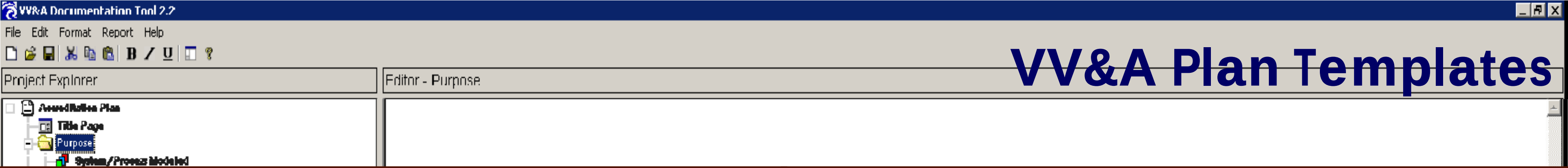
A-i

NMSO VV&A Sample | V:\Documents and Settings\HKH\Desktop\nmsovva.vva

Start | M&S VDT Tool - Microsoft... | VVADOC - Citrix MetaFra... | Adobe Photoshop | VDT2.2 | iTunes | VV&A Documentation...

Vision for Standardized VV&A Docs

VV&A Plan Templates



M&S Requirements Acceptability Criteria	Test Areas & Assessment Tasks of M&S Fidelity

3. ACCREDITATION PLAN TEMPLATE

ACCREDITATION PLAN EXECUTIVE SUMMARY. *"What is the overall purpose of the Accreditation Plan?" The Accreditation Plan provides the executive with an introduction to the Accreditation Plan, leaving granular details to the body of the document. This section is a précis of the major elements from all sections, emphasizing Sections 3, 4, and 7. The Executive Summary is the last section to be written and should be no longer than two-four pages, as no material is provided that is not covered in greater detail in the body of the document. The Executive Summary should be a stand-alone document.*

Upon review, does the Executive Summary:

- *Function as a stand-alone document?*
- *Provide a condensed précis of the Accreditation Plan?*
- *Exclusively provide information that is covered in the body of the Accreditation Plan?*

1. PURPOSE. *"Why is the use of M&S required?" and "What is the purpose of the accreditation?" This section details the context of M&S use and the purpose for the accreditation. This section provides a broad overview of the environment into which M&S will be inserted: program overview, program objectives, background information regarding the need for M&S to meet particular program objectives, etc. The Purpose Section and its subsections (System/Process Modeled, Concept of Operations, and Use of M&S) provide high-level overviews justifying the use of M&S generally and should not address the particular M&S specifically.*

a. System/Process Modeled. *"What is the system or process being modeled?" This subsection describes in detail the system or process that is being modeled or simulated, including the role the system/process will play in the overall program with respect to the program's objectives and goals. The System/Process Modeled provides a high-level overview justifying the use of M&S generally and should not address the particular M&S specifically.*

b. Concept of Operations. *"What is the concept of operations, or conceptual overview, for how the system/process being modeled will be used?" This subsection describes the program's concept of operations with respect to the environment in which the M&S will be inserted. The DoD Dictionary of Military Terms defines the Concept of Operations as "a verbal or graphic statement, in broad outline, of a commander's assumptions or intent in regard to an operation or series of operations.... The concept is designed to give an overall picture of the operation." The Concept of Operations provides a high-level conceptual overview justifying the use of M&S generally and should not address the particular M&S specifically.*

c. Use of M&S. *"How will M&S be applied in the program?" This subsection provides a detailed justification for the use of M&S. The justification should include how M&S will be incorporated into the overall program and the program objectives its use will fulfill, such as the expected output, how the output data will be applied in*

4. VERIFICATION AND VALIDATION PLAN TEMPLATE

V&V PLAN EXECUTIVE SUMMARY. *"What is the overall purpose of the V&V Plan?" The V&V Plan provides the executive with an introduction to the V&V Plan, leaving granular details to the body of the document. This section is a précis of the major elements from all sections, emphasizing Sections, 2, 3, and 7. The Executive Summary is the last section to be written and should be no longer than four pages, as no material is provided that is not covered in greater detail later in the document.*

Upon review, does the Executive Summary:

- *Provide a condensed précis of the body of the V&V Plan?*
- *Function as a stand-alone document, providing a broad yet accurate overview of the V&V Plan as a whole?*
- *Exclusively provide information that is covered in the body of the V&V Plan?*

1. PURPOSE. *"Why is the use of M&S required?" and "What is the purpose of the V&V?" This section details the context of M&S use and the purpose for the V&V. This section provides a broad overview of the environment into which M&S will be inserted: program overview, program objectives, background information regarding the need for M&S to meet particular program objectives, etc. The Purpose Section and its subsections (System/Process Modeled, Concept of Operations, and Use of M&S) provide high-level overviews justifying the use of M&S generally and should not address the particular M&S specifically.*

(As the information in this entire section is common to all four of the core documents, this section may be leveraged from the Accreditation Plan.)

a. System/Process Modeled. *"What is the system or process being modeled?" This subsection describes in detail the system or process that is being modeled or simulated, including the role the system/process will play in the overall program with respect to the program's objectives and goals. The System/Process Modeled provides a high-level overview justifying the use of M&S generally and should not address the particular M&S specifically.*

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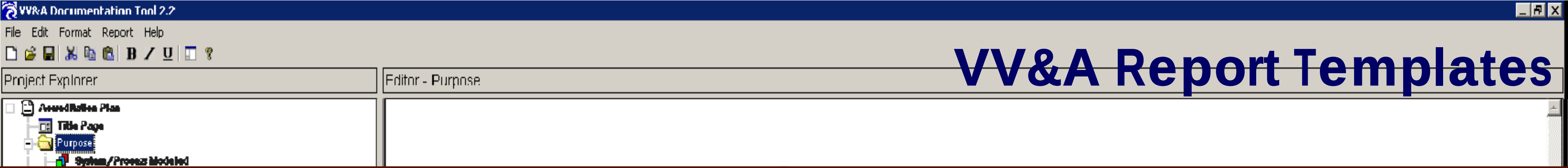

VV&A Report Templates

Report on Inspect Results

5. VERIFICATION AND VALIDATION REPORT TEMPLATE

V&V REPORT EXECUTIVE SUMMARY. *"What is the overall purpose of the V&V Report?" The V&V Report provides the executive with an introduction to the V&V Report, leaving granular details to the body of the document. This section is a précis of the major elements from all sections, emphasizing Sections 3, 4, 5, and 7. The Executive Summary is the last section to be written and should be no longer than four pages, as no material is provided that is not covered in greater detail later in the document.*

Upon review, does the Executive Summary:

- *Provide a condensed précis of the body of the Accreditation Plan?*
- *Function as a stand-alone document, providing a broad yet accurate overview of the Accreditation Plan as a whole?*
- *Exclusively provide information that is covered in the body of the Accreditation Plan?*

1. PURPOSE. *"Why is the use of M&S required?" and "What is the purpose of the accreditation?" This section details the context of M&S use and the purpose for the accreditation. This section provides a broad overview of the environment into which M&S will be inserted: program overview, program objectives, background information regarding the need for M&S to meet particular program objectives, etc. The Purpose Section and its subsections (System/Process Modeled, Concept of Operations, and Use of M&S) provide high-level overviews justifying the use of M&S generally and should not address the particular M&S specifically.*

(As the information in this entire section is common to all four of the core documents, this section may be leveraged from the Accreditation Plan and V&V Plan.)

a. System/Process Modeled. *"What is the system or process being modeled?" This subsection describes in detail the system or process that is being modeled or simulated, including the role the system/process will play in the overall program with respect to the program's objectives and goals. The System/Process Modeled provides a high-level overview justifying the use of M&S generally and should not address the particular M&S specifically.*

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Report on M&S Acceptability

7. ACCREDITATION REPORT TEMPLATE

ACCREDITATION REPORT EXECUTIVE SUMMARY. *"What is the overall purpose for the Accreditation Report?" The Accreditation Report provides the executive with an introduction to the Accreditation Report, leaving granular details to the body of the document. This section is a précis of the major elements from all sections, emphasizing Sections 3, 4, and 5. The Executive Summary is the last section to be written an should be no longer than eight pages in length, as no material is provided that is not covered in greater detail later in the document.*

Upon review, does the Executive Summary:

- *Provide a condensed précis of the body of the Accreditation Report?*
- *Function as a stand-alone document, providing a broad yet accurate overview of the Accreditation Report as a whole?*
- *Exclusively provide information that is covered in the body of the Accreditation Report?*

1. PURPOSE. *"Why is the use of M&S required?" and "What is the purpose of the accreditation?" This section details the context of M&S use and the purpose for the accreditation. This section provides a broad overview of the environment into which M&S will be inserted: program overview, program objectives, background information regarding the need for M&S to meet particular program objectives, etc. The Purpose Section and its subsections (System/Process Modeled, Concept of Operations, and Use of M&S) provide high-level overviews justifying the use of M&S generally and should not address the particular M&S specifically.*

(As the information in this entire section is common to all four of the core documents, this section may be leveraged from the Accreditation Plan, V&V Plan, and V&V Report.)

a. System/Process Modeled. *"What is the system or process being modeled?" This subsection describes in detail the system or process that is being modeled or simulated, including the role the system/process will play in the overall program with respect to the program's objectives and goals. The System/Process Modeled provides a high-level overview justifying the use of M&S generally and should not address the particular M&S specifically.*

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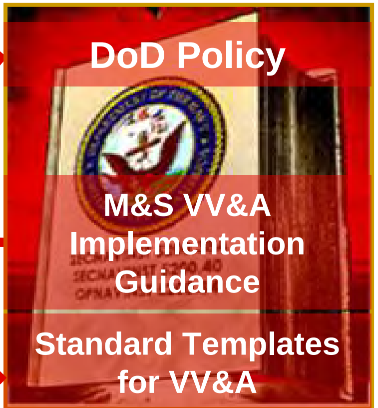
Overview of the VDT

Infrastructure = VDT

"Policies, standards, process, VV&A, and use-specific databases" -RAND

DoD Users

?



M&S Public Info.

VV&A Documentation Tool 2.2

File Edit Format Report Help

Infrastructure = VDT

Project Explorer

- Accreditation Plan
  - Title Page
  - Purpose
    - System/Process Modeled
    - Concept of Operations
    - Use of M&S
    - Background
  - M&S Intended Use
    - Objectives
    - M&S Requirements
    - M&S Limitations
    - Constraints
    - M&S Risk Management
  - Acceptability Criteria
    - Acceptability Issues & Criteria
    - Acceptability Criteria Measures & Metrics
  - M&S Description
    - M&S History
    - M&S Development
    - M&S Variables
    - M&S Inputs/Ouputs
    - Configuration Management
  - Accreditation Resources
    - Accreditation Funding
    - Accreditation Timeline
  - Accreditation Issues
  - Key Participants
  - Accreditation Methodology
  - Accreditation Plan Summary
  - Bibliography
  - Acronyms
  - Glossary
  - Accreditation Distribution List
  - Accreditation Plan Executive Summary

Purpose

Describe, in general, why the use of modeling and simulation is needed. Describe the purpose for accreditation. Describe events the model or simulation (M&S) will support.

Editor - Purpose

"Policies, standards, process, VV&A, and use-specific databases" -RAND

Navy Users

VV&A Documentation Tool

SECNAVINST 5200.40

DON M&S VV&A Implementation Handbook, Vol.1

Standard Templates for VV&A Documentation

M&S Public Info.

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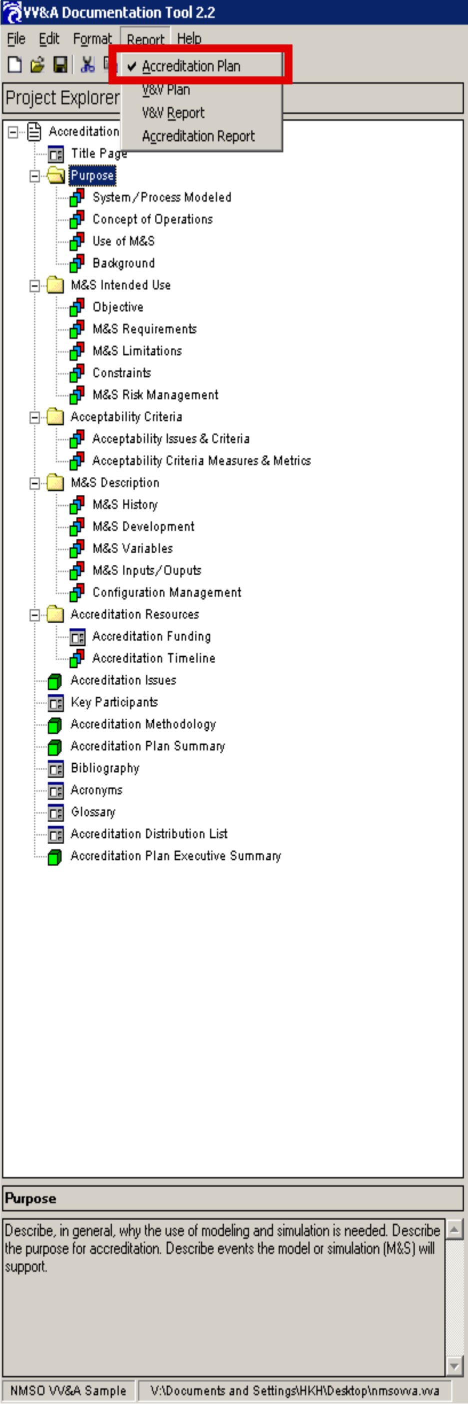
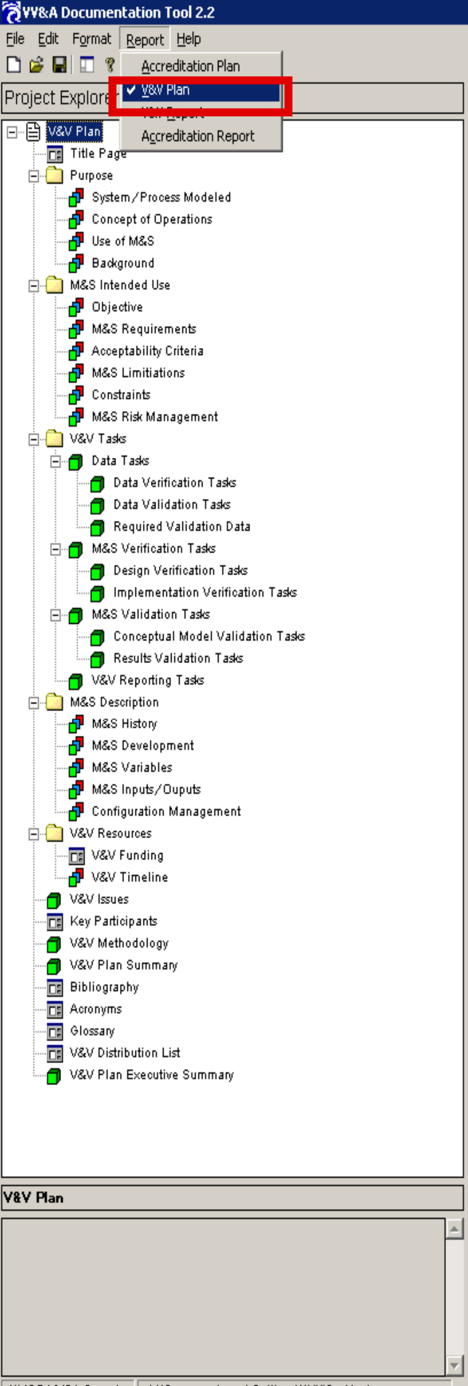
Start | M&S VDT Tool - Microsoft... | VVADOC - Citrix MetaFra... | Adobe Photoshop | VDT2.2 | iTunes | VV&A Documentation...

Four Core Documents

- From M&S Development to M&S Fidelity:
  - Accreditation Plan
    - M&S Requirements
    - Acceptability Criteria



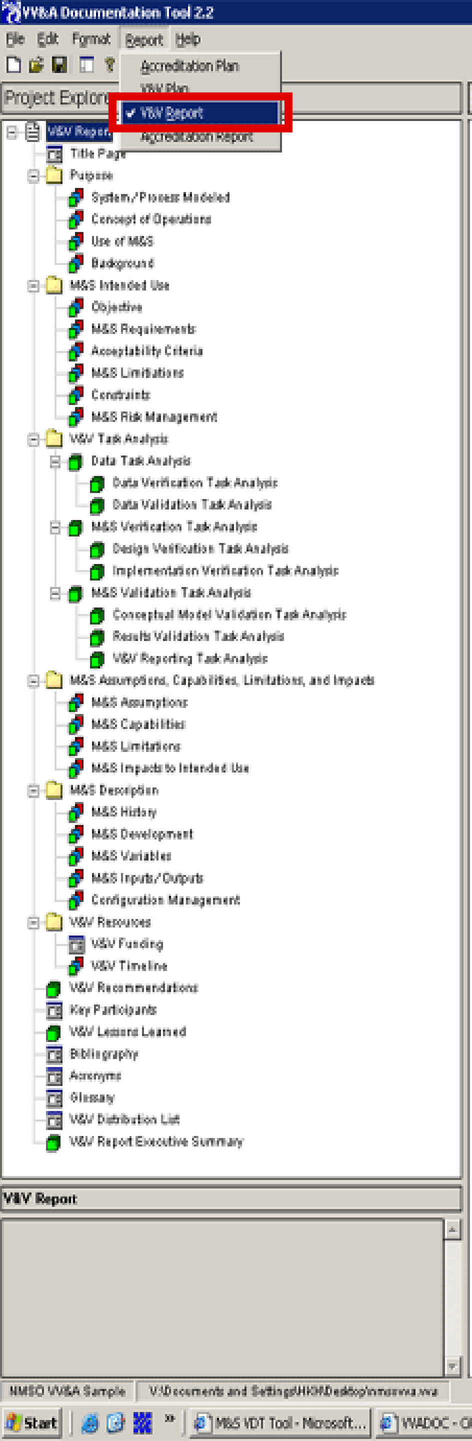
Four Core Documents

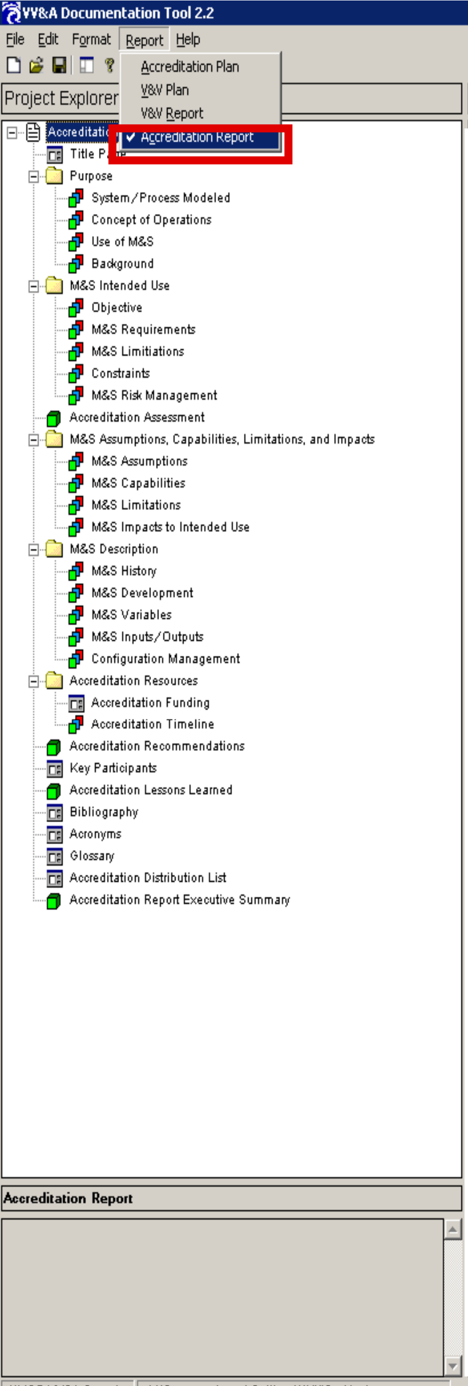


- From M&S Development to M&S Fidelity:
  - Accreditation Plan
    - M&S Requirements
    - Acceptability Criteria
  - V&V Plan
    - Test Areas
    - Tasks to Test M&S Fidelity

Four Core Documents

- **From M&S Development to M&S Fidelity:**
  - **Accreditation Plan**
    - **M&S Requirements**
    - **Acceptability Criteria**
  - **V&V Plan**
    - **Test Areas**
    - **Tasks to Test M&S Fidelity**
  - **V&V Report**
    - **Inspection Results**





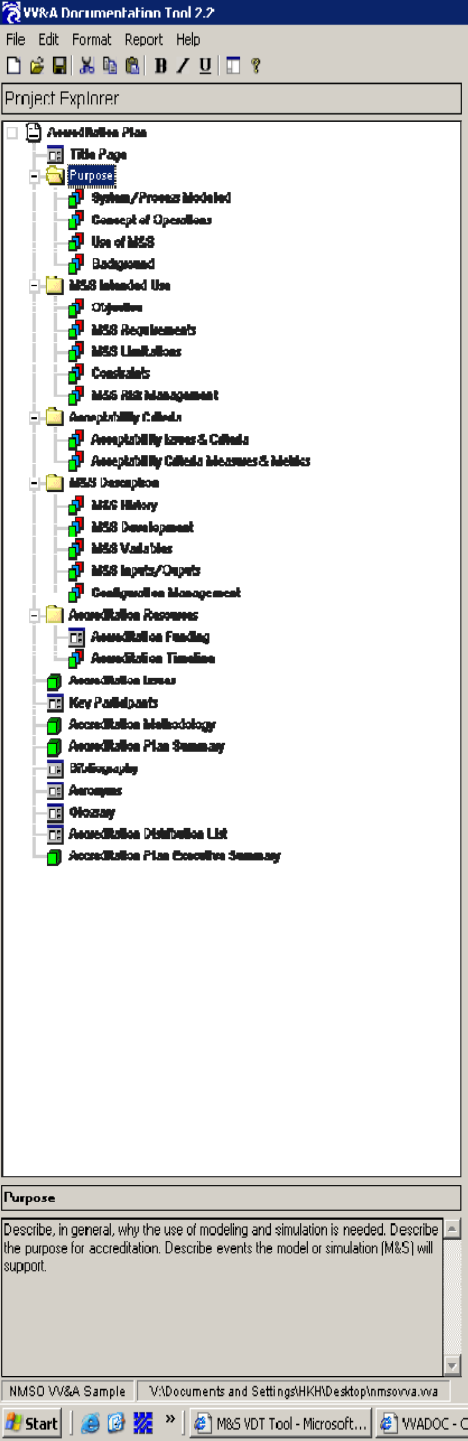
Four Core Documents

Editor - Accreditation Report

- From M&S Development to M&S Fidelity:
  - Accreditation Plan
    - M&S Requirements
    - Acceptability Criteria
  - V&V Plan
    - Test Areas
    - Tasks to Test M&S Fidelity
  - V&V Report
    - Inspection Results
  - Accreditation Report
    - Results of Acceptability Assessment

Benefits of the VDT

VV&A Documentation Tool



- Standardizes and automates production of VV&A documentation
- Supports VV&A policy and guidance
- Promotes M&S Reuse
- Leverages web-based and XML technologies
- User friendly; what you see is what you get

Assured Security

M&S VDT Portal Login

US Department of Defense Warning Statement

This is a Department of Defense computer system. This computer system, including all related equipment, networks and network devices (specifically including Internet access), are provided only for authorized U. S. Government use. DoD computer systems may be monitored for all lawful purposes, including to ensure that their use is authorized, for management of the system, to facilitate protection against unauthorized access, and to verify security procedures, survivability and operational security. Monitoring includes active attacks by authorized DoD entities to test or verify the security of this system. During monitoring, information may be examined, recorded, copied and used for authorized purposes. All information, including personal information, placed on or sent over this system may be monitored. Use of this DoD computer system, authorized or unauthorized, constitutes consent to monitoring of this system. Unauthorized use may subject you to criminal prosecution. Evidence of unauthorized use collected during monitoring may be used for administrative, criminal or adverse action. Use of this system constitutes consent to monitoring for these purposes

User Name:

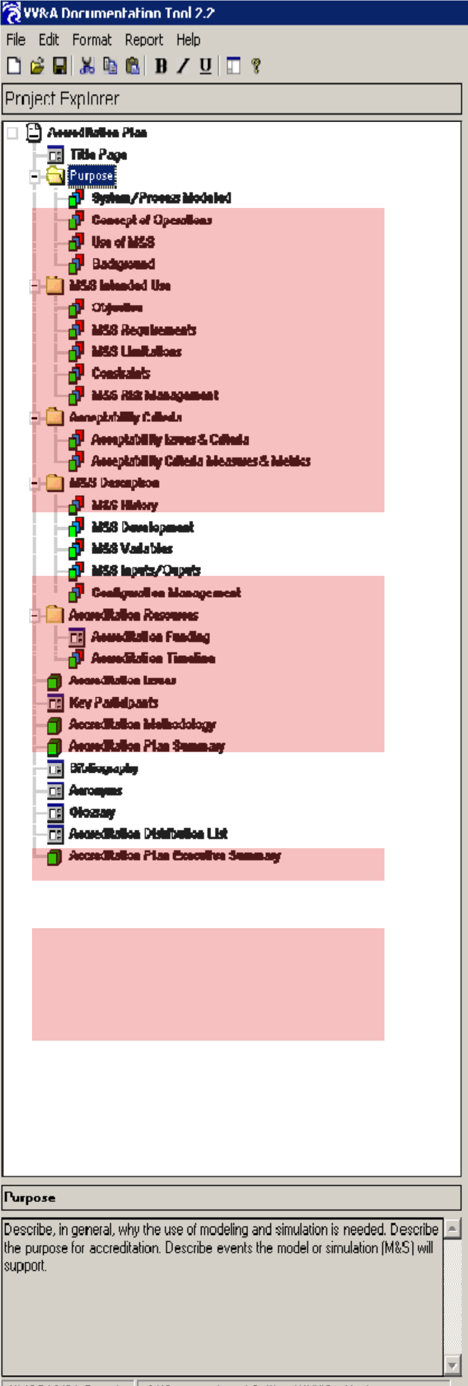
Password:

Login

DON: Conformity to DOD network security standards

Users: Transparency of information among team members while preserving security for proprietary information

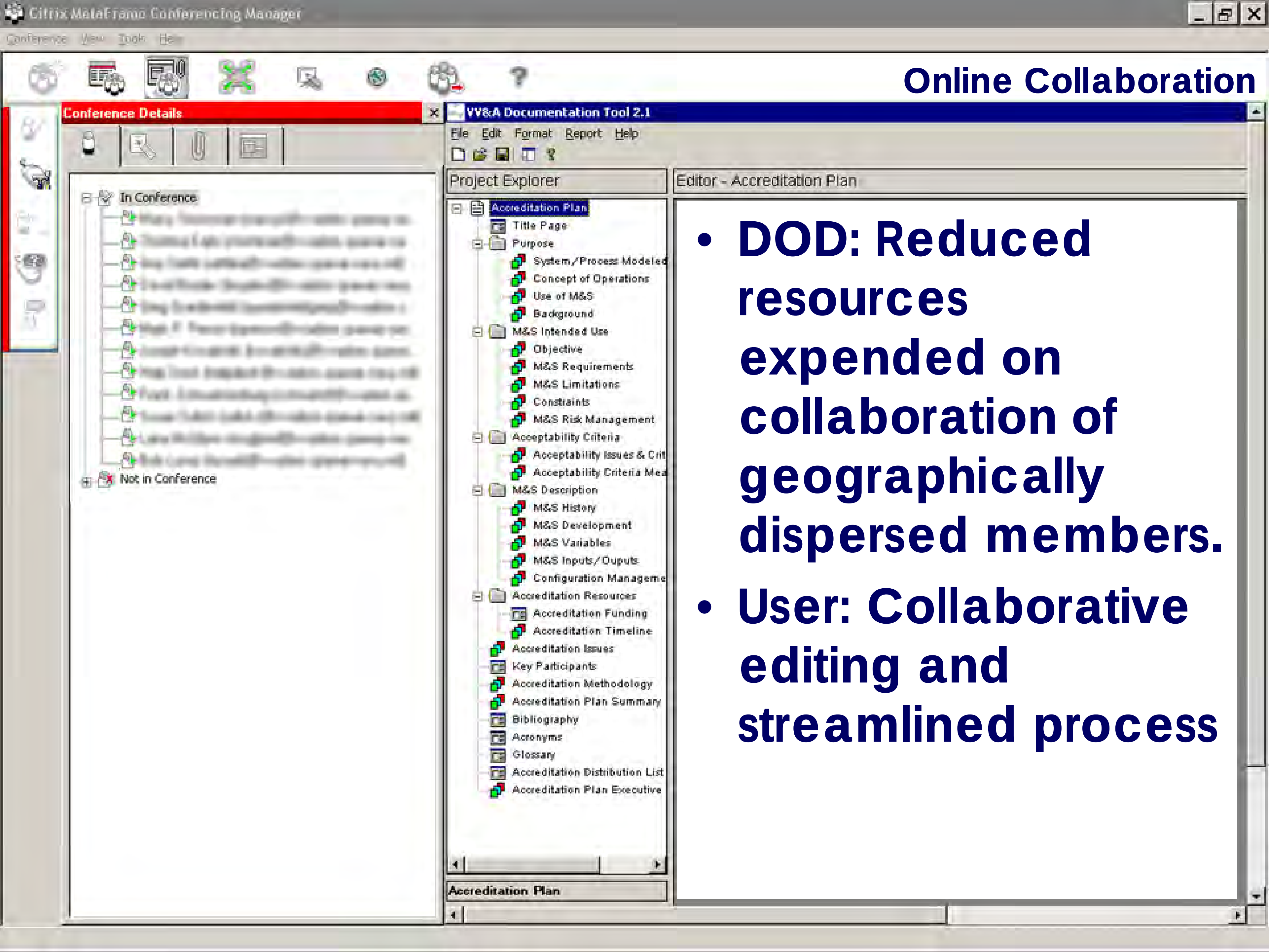
Data-Aware Application



- DOD
  - Consistent information across all documents
  - Data capture to the NMSIS
- User
  - Elimination of Redundant Data Entry

As a data-aware application, common information regarding the M&S (Description, CONOPs, Use History, etc) are propagated across all four documents, reducing the resources expended on repetitive reporting of duplicate information. Further, this M&S metadata will be captured in the M&S Repository.

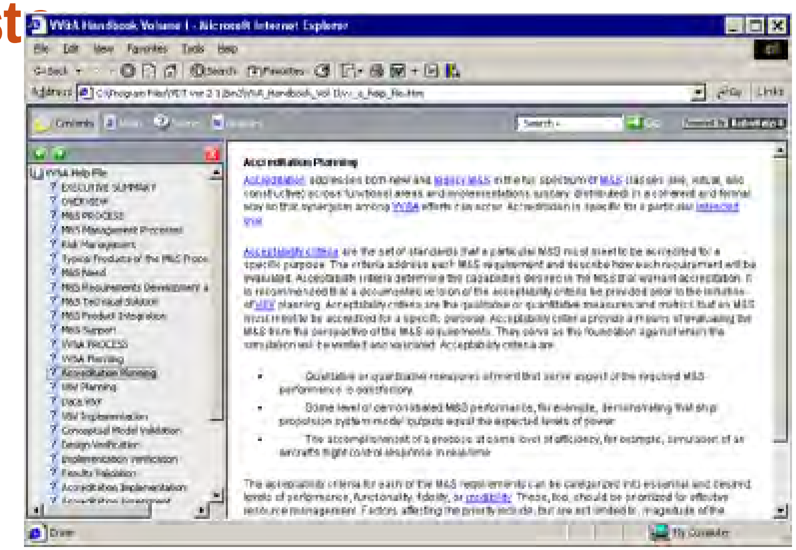
Online Collaboration



- **DOD: Reduced resources expended on collaboration of geographically dispersed members.**
- **User: Collaborative editing and streamlined process**

Benefits to the User

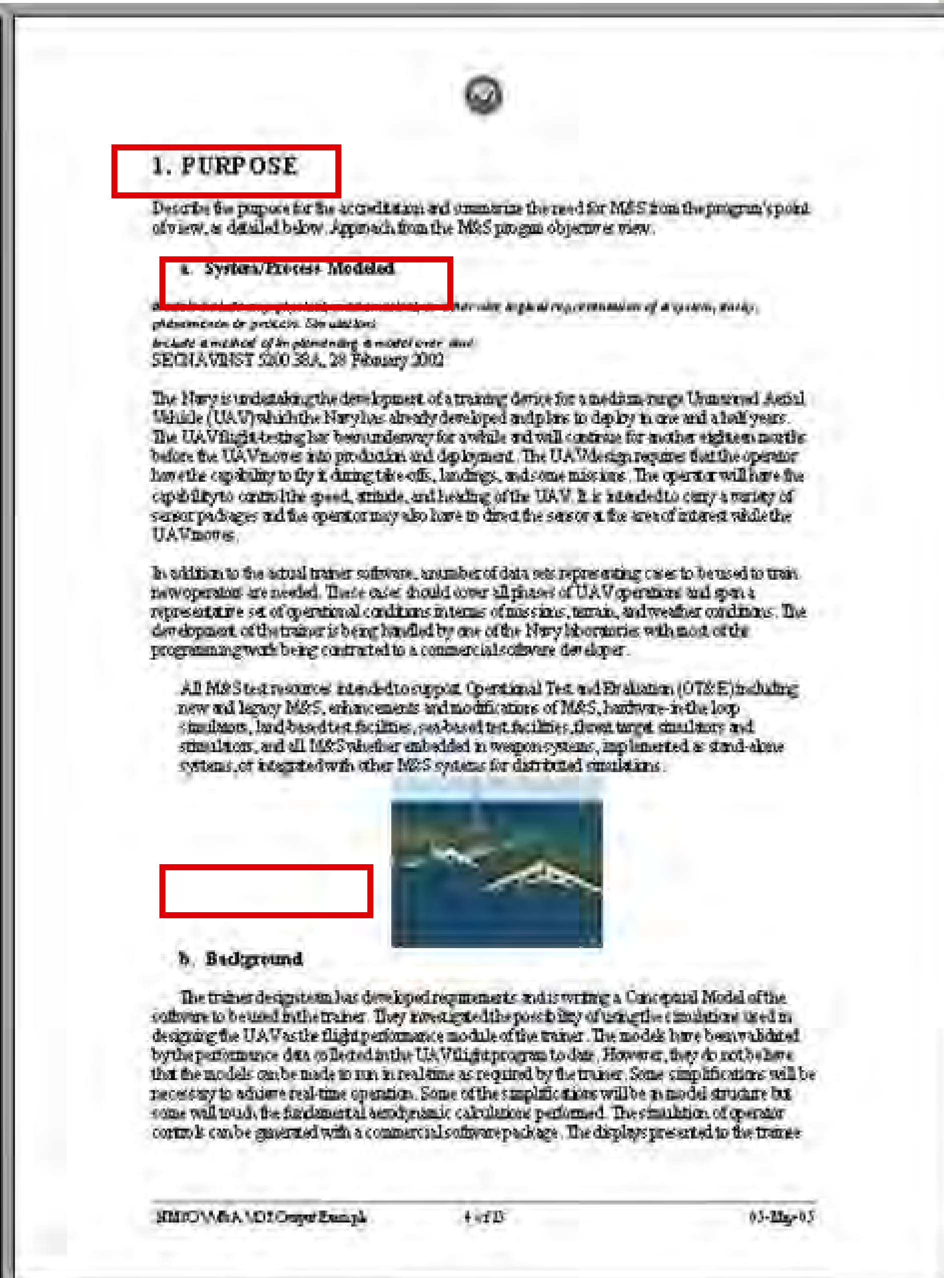
- **Document consistently and holistically**
  - **VV&A-specific framework**
- **Do more in less time**
  - **Foundation: DOD VV&A policy**
  - **References**
  - **Cut-and-paste**



Bottom Line: Let's not reinvent the wheel. Reduce document-delivery time by <u>not</u> starting with a blank slate.

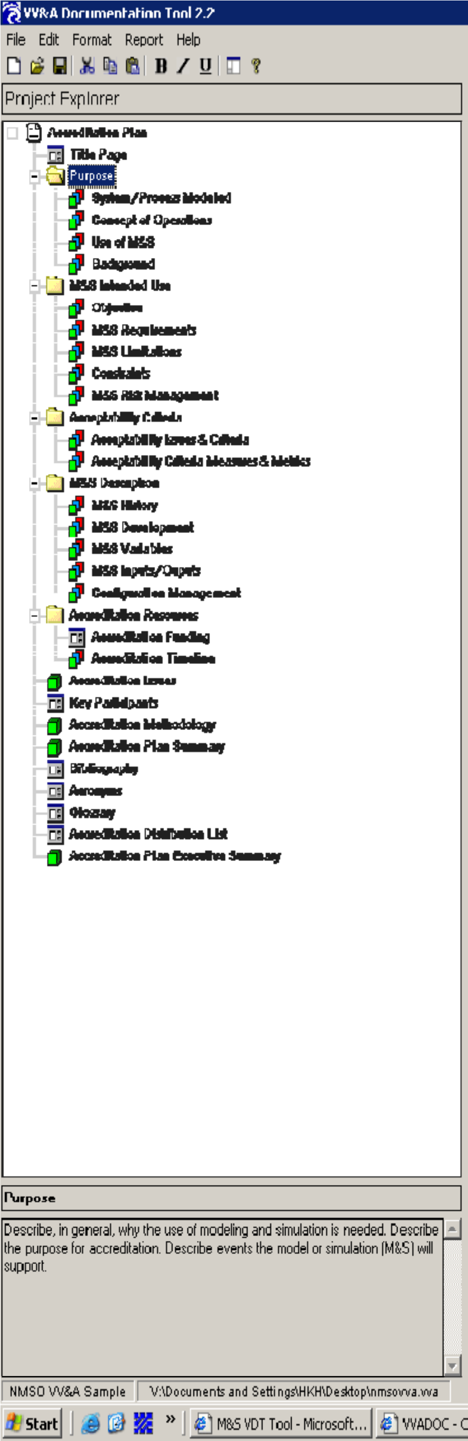
Taking the Guesswork Out of VV&A

- **Publish to Word**
  - Print to your local printer quickly & efficiently
  - Polish your published documents to fit your organization's preferences
- **Benefits**
  - DON: Standardized artifacts for all DON M&S
  - User: Conformity to DON VV&A precepts while preserving the flexibility required to tailor VV&A according to need



How Does Standardization Help You?

- **Resources not wasted** deciding what information to include and format
- **Increased understanding** of the intended use and thoroughness of technical evidence
- **Completeness** instills **confidence** in reviewers and decision makers
- Supports **future reuse** of information in documents to support the next accreditation

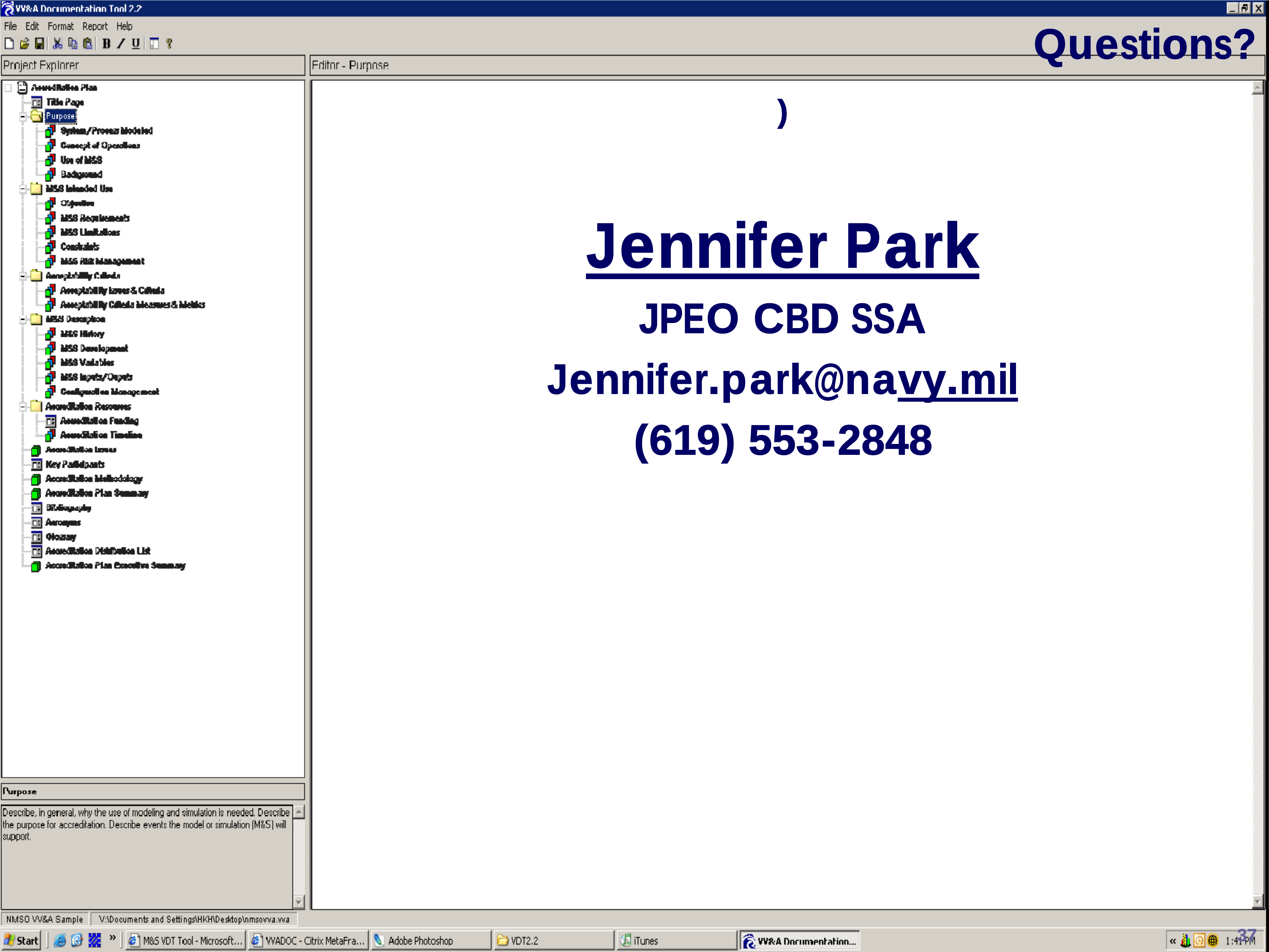


THE BOTTOM LINE –
Summary and Recap

Summary

- VV&A documentation standardization benefits everyone
- VV&A Documentation Tool might offer an 80% solution to meet your needs
- Working together we can improve the tool to everyone’s satisfaction

Questions?



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JPEO CBD SSA

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Assessing the Impact of Meteorological Model Uncertainty on SCIPUFF AT&D Predictions

2007 Chemical Biological Information Systems Conference & Exhibition
8-11 January 2007

L.J. Peltier[1], J.C. Wyngaard[2], S. E. Haupt[1,2], D.R. Stauffer[2], & A.J. Deng[2], J. Lee[1,2], & B. Reen[2]
Applied Research Lab[1] & Dept. of Meteorology[2]
Penn State University

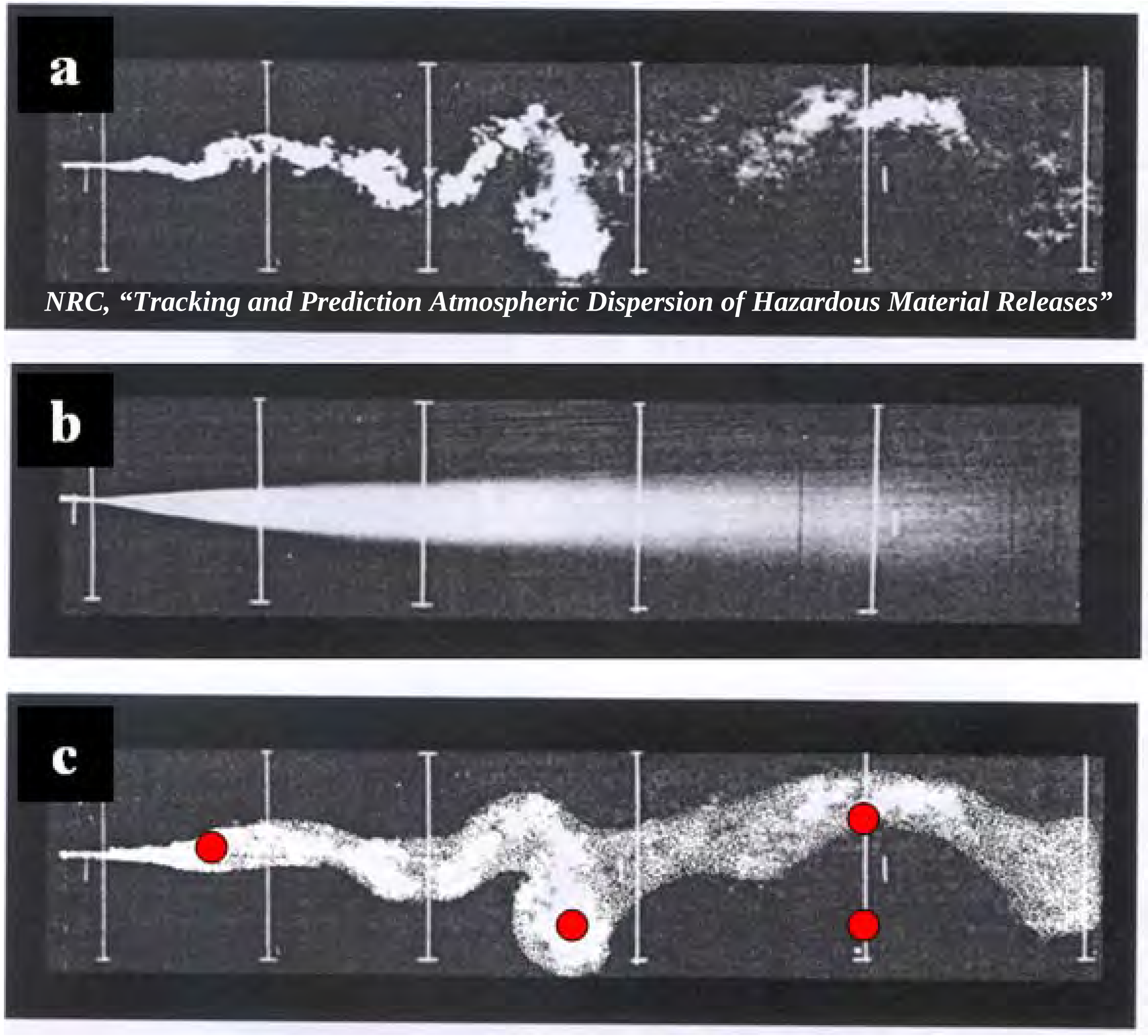
Sponsored/Supported by
S. Hamilton (DTRA) and C. Kiley (Northrop Grumman)

Motivation

- Many physics-based atmospheric transport and dispersion (AT&D) models, e.g. SCIPUFF, derive their transporting wind field from meteorological (met) models *– met model winds*
- These AT&D and met models are sophisticated interplays of physics and parameterizations that have evolved over many years *– good T&D models*
- Given adequate initial and boundary conditions, these models can successfully reproduce dispersion episodes *– sensitive to ics & bcs*
- In a limited domain model, an ensemble of simulations can be used to include the statistical effects of large-scale (*outer*) variability *– dispersion uncertainty arises from met ensemble uncertainty*

Background

- *Realization*
  The actual wind field for a dispersion event
- *Statistic*
  Ensemble Mean Plume
- *Conditional Statistic*
  Reduced uncertainty through NWP skill



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Background

- *Realization*
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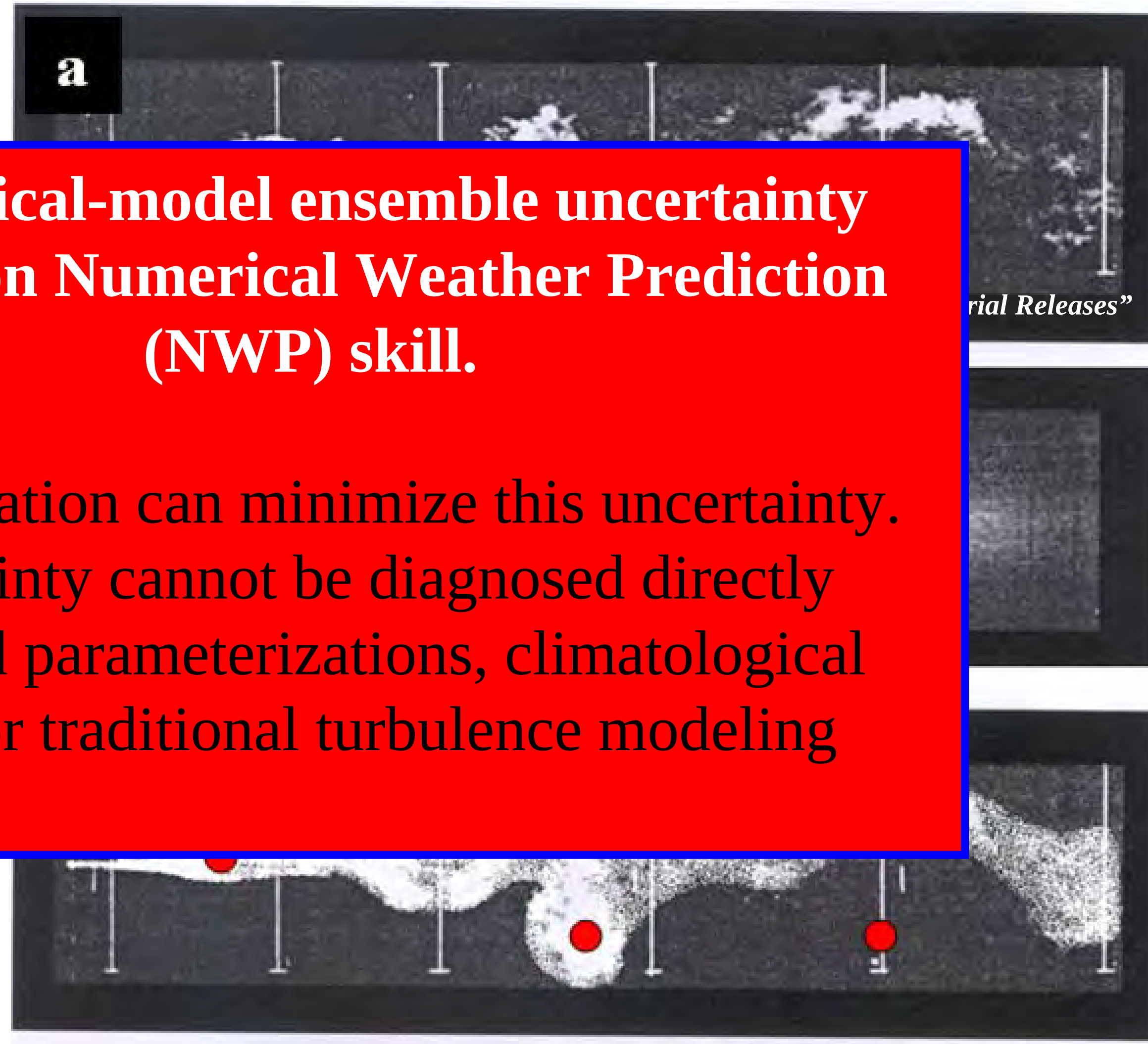
  Reduce
  through NWP skill



Meteorological-model ensemble uncertainty depends on Numerical Weather Prediction (NWP) skill.

- Data assimilation can minimize this uncertainty.
- This uncertainty cannot be diagnosed directly from subgrid parameterizations, climatological variability, or traditional turbulence modeling approaches.

Goal and Approach/Outline

To parameterize meteorological model uncertainty for dispersion

- Representation
  - Evaluate meteorological model uncertainty from meteorological model ensemble variability
- Theory
  - Use Taylor dispersion arguments applied to ensemble dispersion to define the uncertainty modeling parameters
- Evaluation
  - Diagnose the uncertainty parameters from ensemble data (this study & related work by Walter Kolczynski, PhD, PSU)
- Modeling
  - Develop operational models for the uncertainty parameters

The Meteorological Ensemble

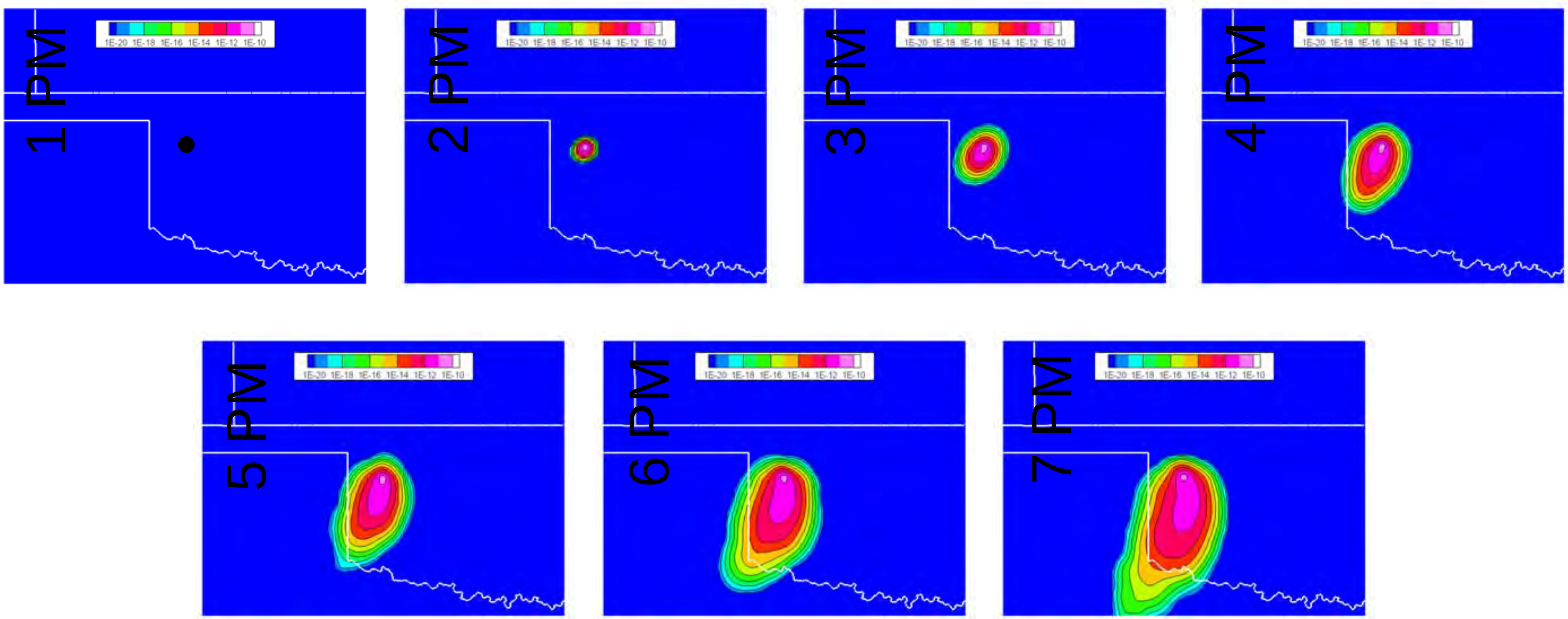
A fair weather day in Oklahoma

- Ensemble 1: *used to evaluate uncertainty modeling parameters*
  - A 29 member MM5 physics ensemble (PhD work of B. Reen, Penn State Meteorology) modeling the IHOP (International H2O Project) field experiment (light winds & precip.)
- Ensemble 2: *used to motivate ensemble uncertainty*
  - Research ensemble (11 members) intentionally constructed to emphasize wind-direction variability
- Other Ensembles: *"real-world" examples*
  - NCEP's SREF operational data
  - MM5 ensemble modeling the CAPTEX (Cross Appalachian Tracer Experiment) field study

Baseline Member of Ensemble 2

6 Hr Release of C7F14; 1 PM to 7 PM Local Time; 5/29/2002

MM5 wind field; SCIPUFF dispersion model



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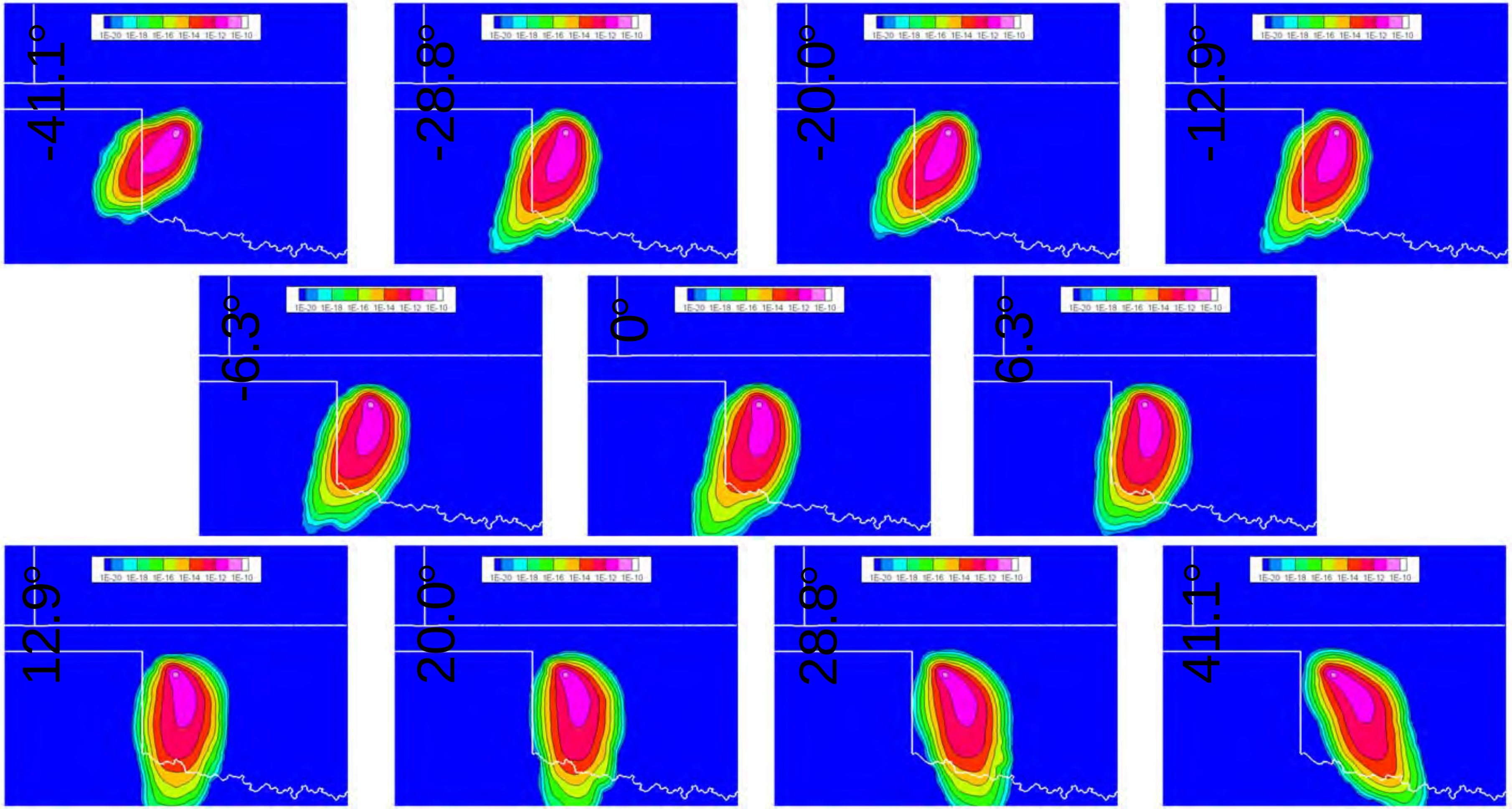
11 Member of Ensemble 2

6 Hr Release of C7F14; 7 PM Local Time; 5/29/2002

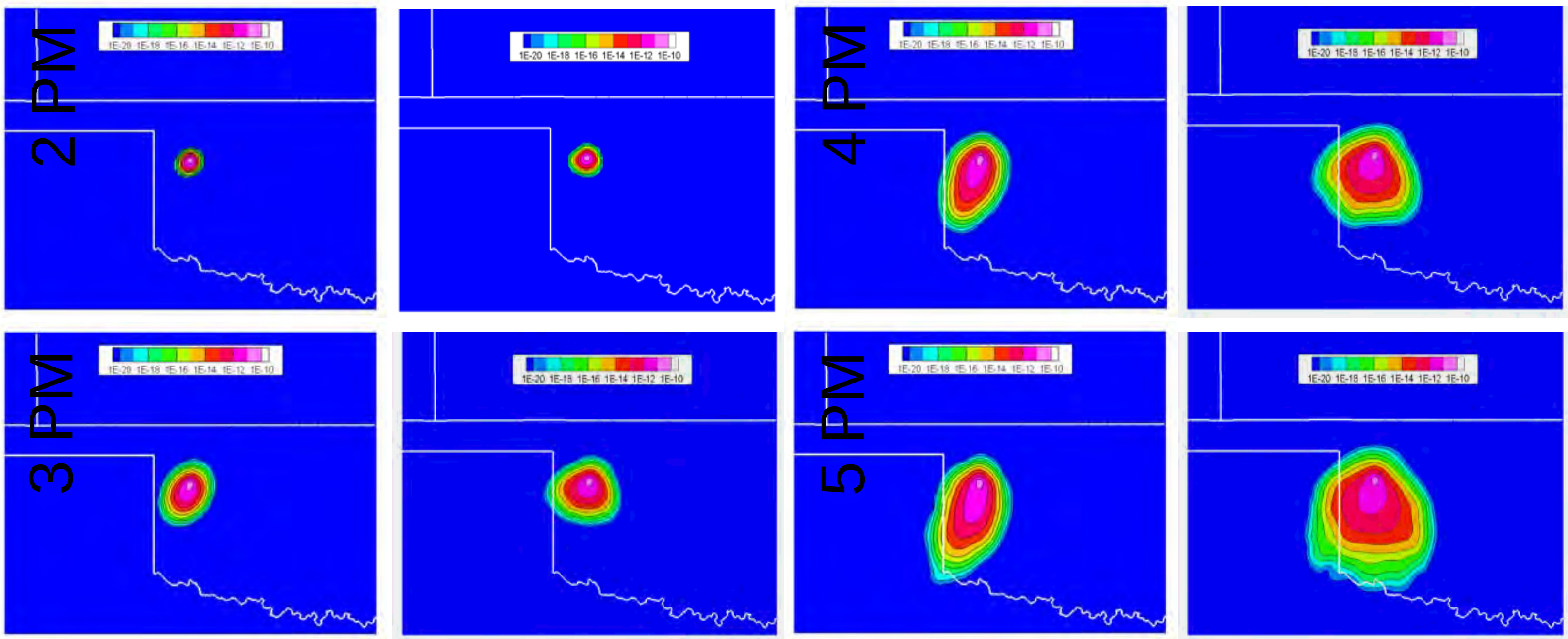


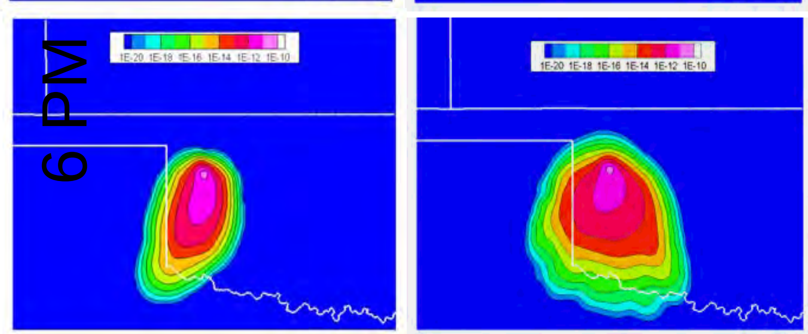
Members constructed to emphasize wind-angle uncertainty

Baseline/Ensemble-Mean Plumes

6 Hr C7F14 Release; 2 PM to 6 PM Local Time; 5/29/2002

Baseline *Ensemble-Mean* *Baseline* *Ensemble-Mean*





- Member- and mean-plume footprint differences depict effects of ensemble uncertainty.

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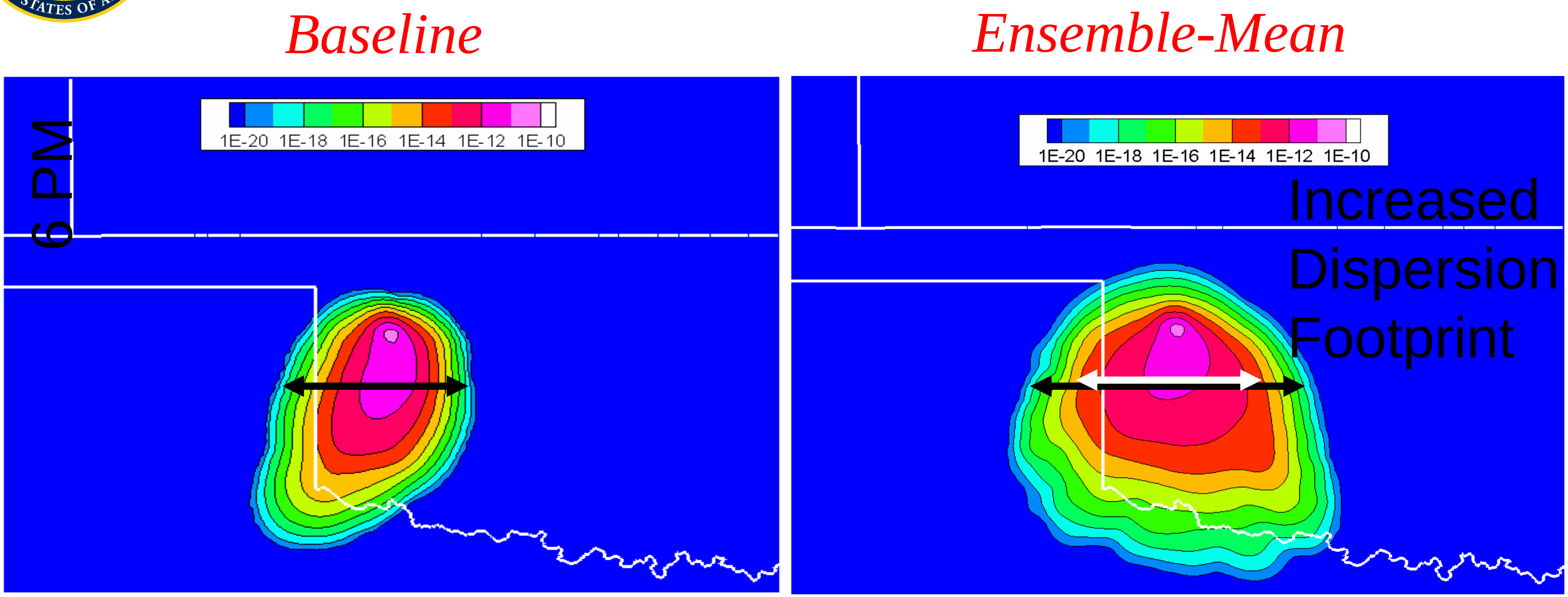
Effects of Wind Direction Variability

6 Hr Release of C7F14; 6 PM Local Time; 5/29/2002



- The mean-plume footprint is larger than the member plume footprint due to meteorological variability.
- The characteristic dispersion length, therefore, is larger.
- Planform differences between these plumes demonstrate the effects of meteorological uncertainty on dispersion.

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Relation to Dispersion Uncertainty

Taylor-dispersion arguments can be used to relate dispersion uncertainty to meteorological model ensemble variability

- The theory describes dispersion in homogeneous environments.
- It isolates Lagrangian velocity and integral-time statistics as the relevant modeling parameters.
- They yield the ensemble-uncertainty model parameters.

Taylor Dispersion

This is a variant of the "Taylor dispersion" problem (Taylor, 1921). Its key parameter is the Lagrangian integral time scale τ_L,

$$\tau_L = \frac{1}{\overline{v^2}} \int_0^\infty \overline{v(t)v(t+\tau)}\, d\tau.$$

The overbar represents the average over a large ensemble of dispersion realizations and v is the lateral velocity of a diffusing particle in coordinates aligned with the ensemble-mean flow.

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Taylor Dispersion

6 Hr C7F14 Release; 2 PM to 6 PM Local Time; 5/29/2002

- The plume width parameter σ has linear and parabolic growth asymptotes

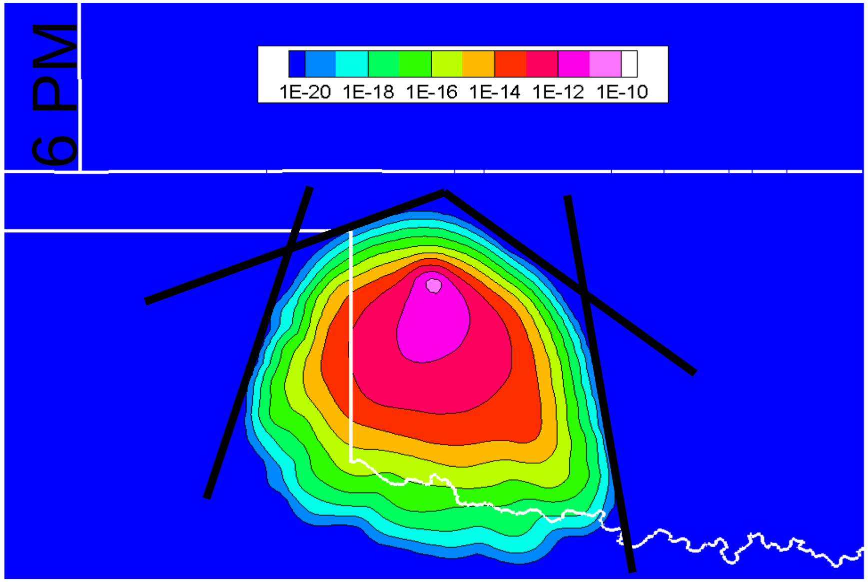
$$\sigma(t) = (\overline{v^2})^{1/2}\, t, \quad t \ll \tau_L$$

$$\sigma(t) = (\overline{v^2}\tau_L)^{1/2}\, t^{1/2}, \quad t \gg \tau_L$$

- A characteristic width parameter is

$$\Lambda \simeq \underline{\tau_L} \times \underline{(\overline{v^2})}^{1/2}$$

Ensemble-Mean



Uncertainy modeling parameters

Uncertainty Parameters

- SCIPUFF parameters UUE, VVE, and UVE can be diagnosed from ensemble deviation-velocity fields
- The Lagrangian integral time can be diagnosed from Lagrangian particle trajectories through the meteorological model data
- SCIPUFF parameter SLE can be diagnosed from the ensemble deviation velocities and the Lagrangian integral time
  - $SLE \sim \tau_L\ (UUE+VVE)^{1/2}$
- Direct evaluation of these parameters from meteorological data provides the "truth" for modeling efforts.

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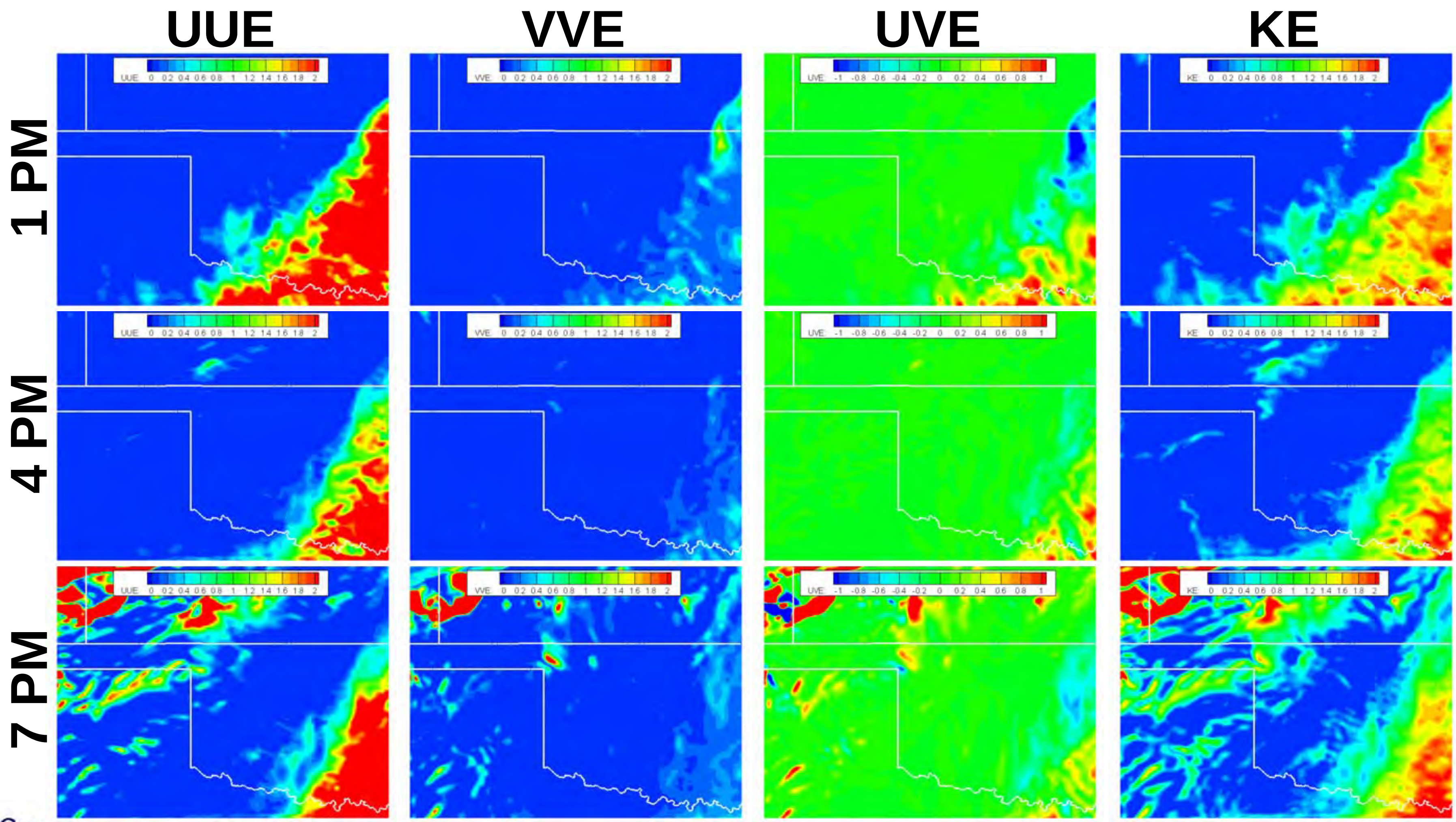
Deviation-Velocity Statistics

Deviation-Velocity Statistics



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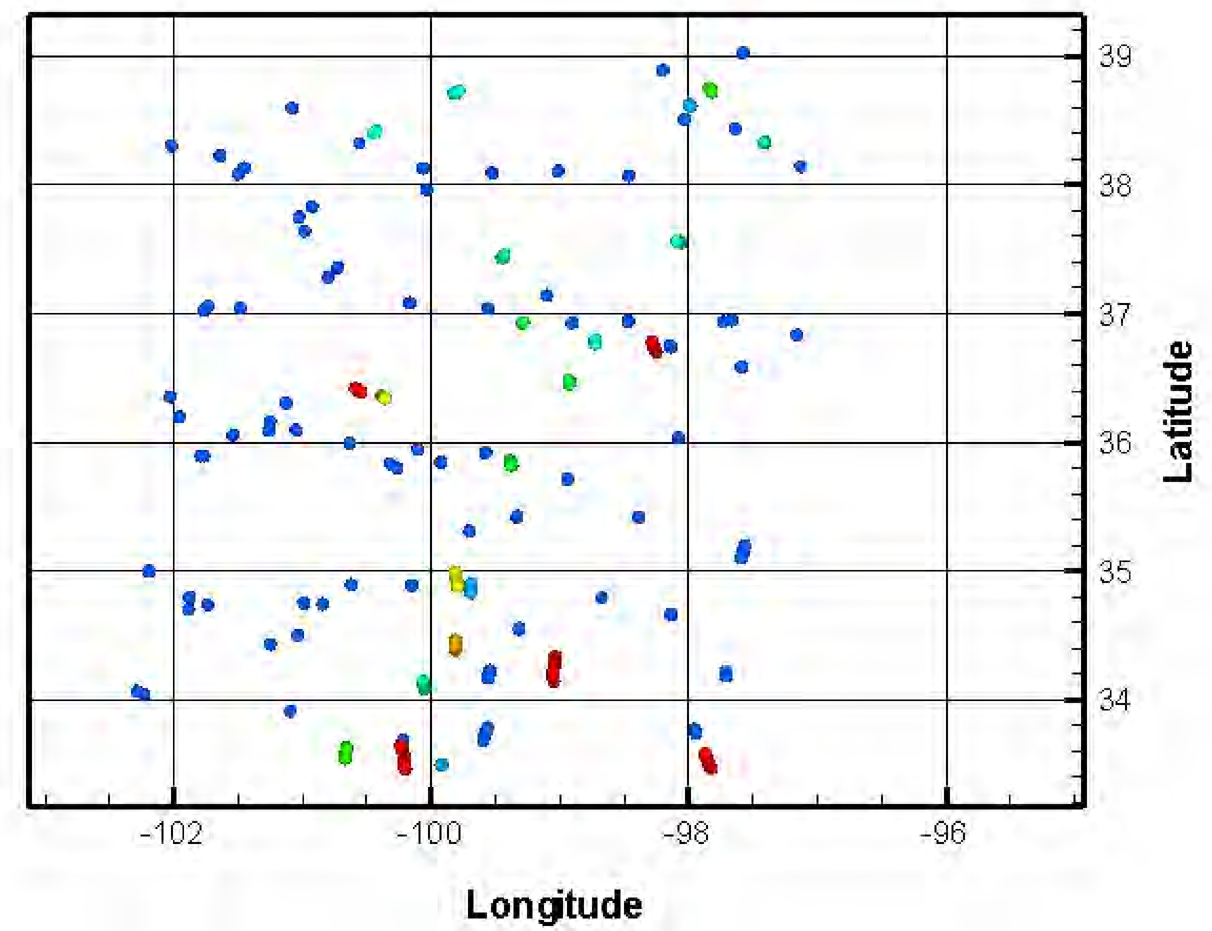
Lagrangian Particle Trajectories

Particle Position at 1 PM

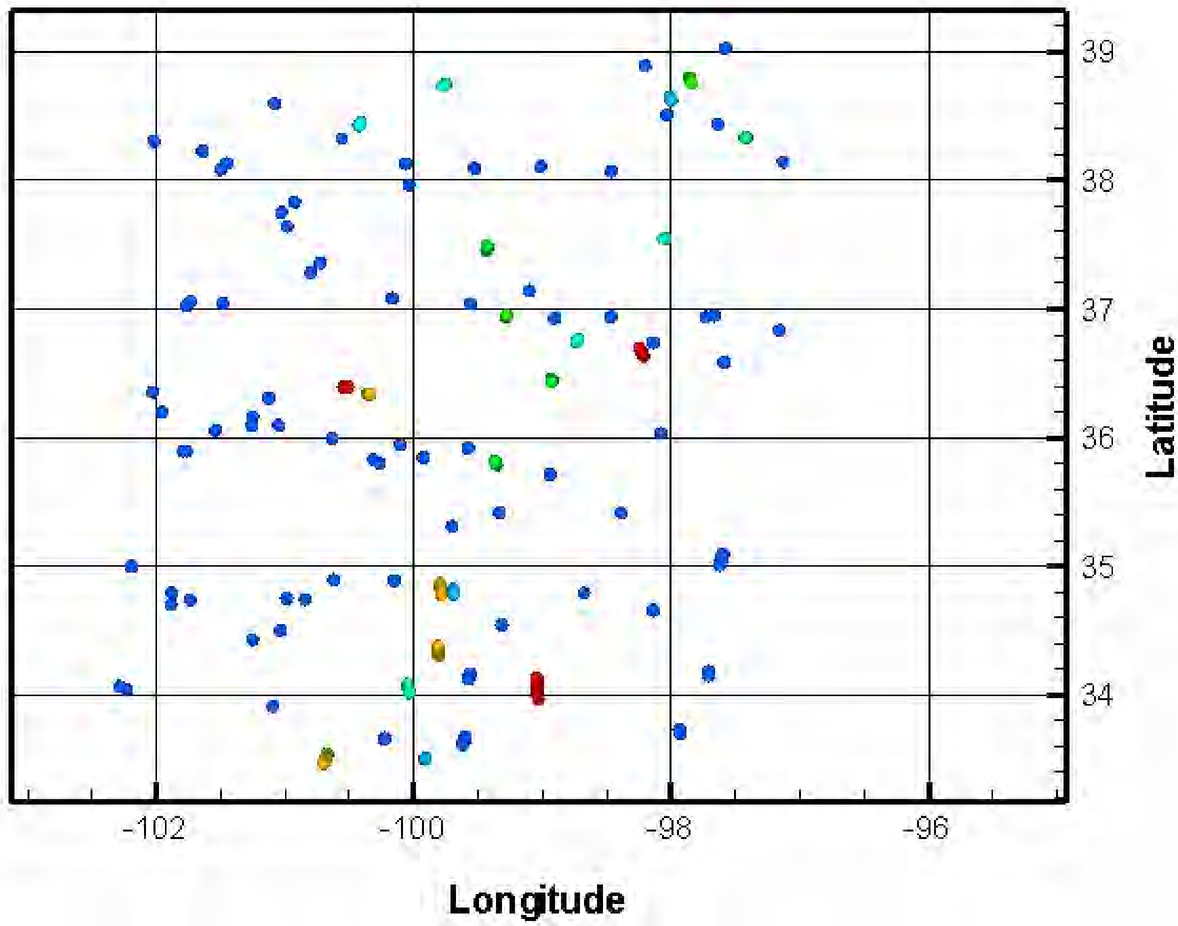
Colored by Height



Lagrangian Particle Trajectories

Particle Position at 2 PM

Colored by Height



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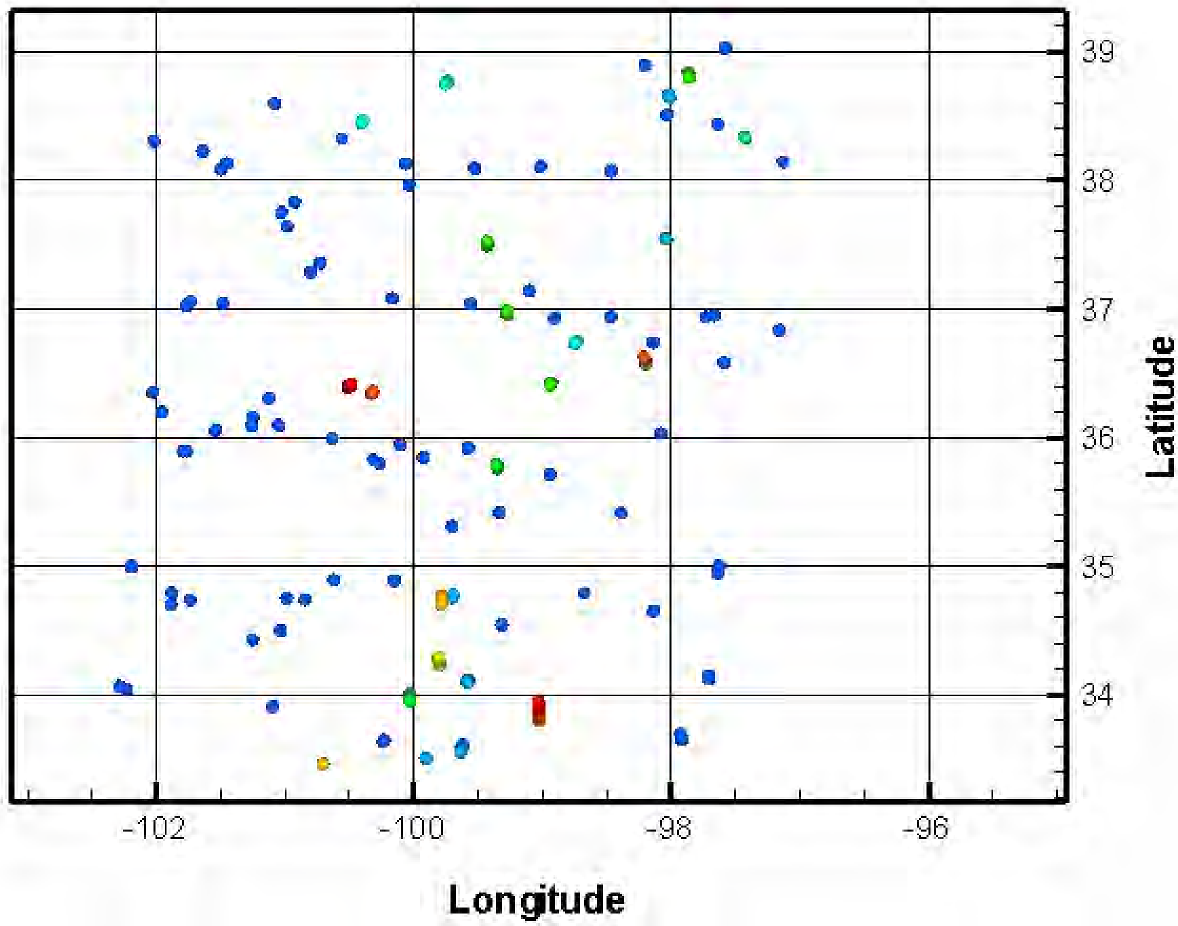
Lagrangian Particle Trajectories

Particle Position at 3 PM

Colored by Height



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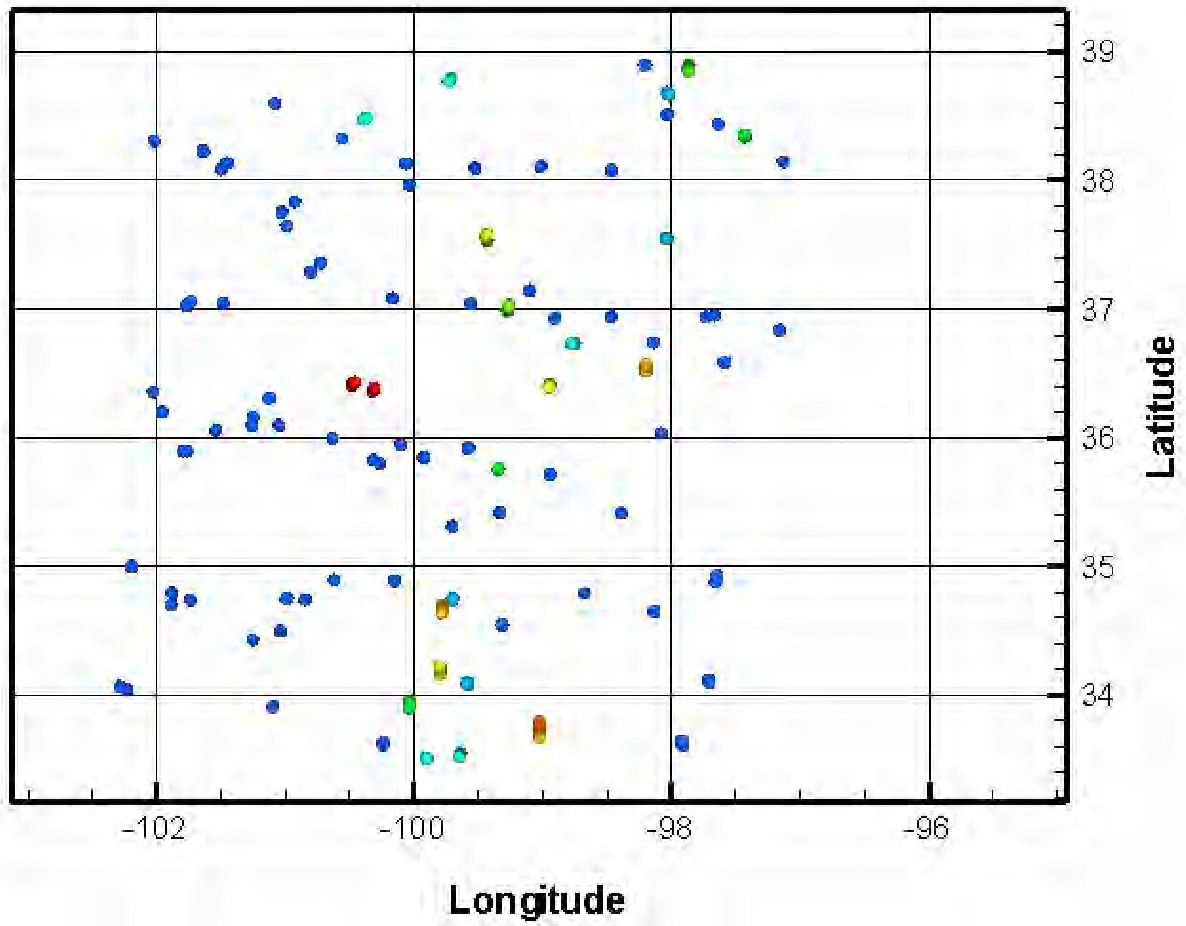
Lagrangian Particle Trajectories

Particle Position at 4 PM

Colored by Height



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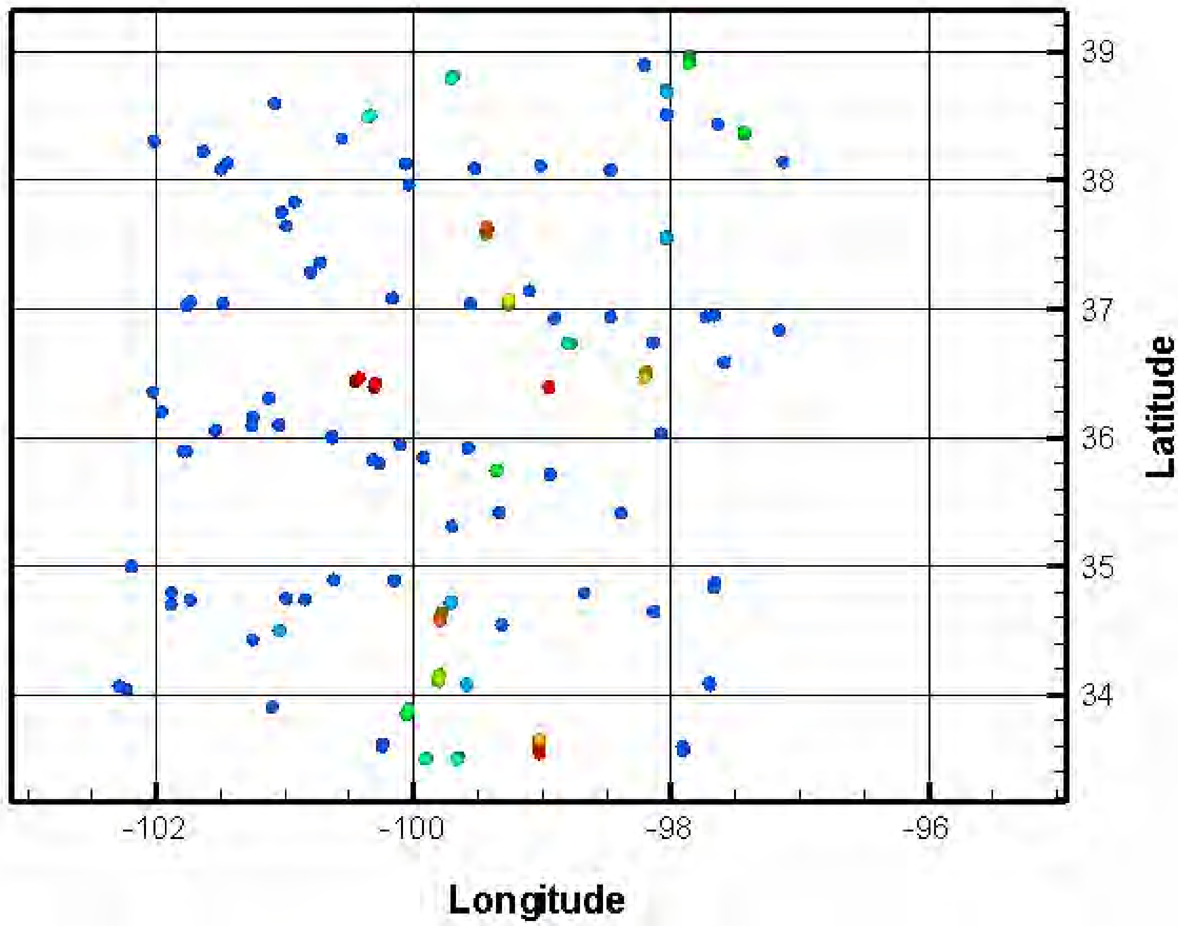
Lagrangian Particle Trajectories

Particle Position at 5 PM

Colored by Height



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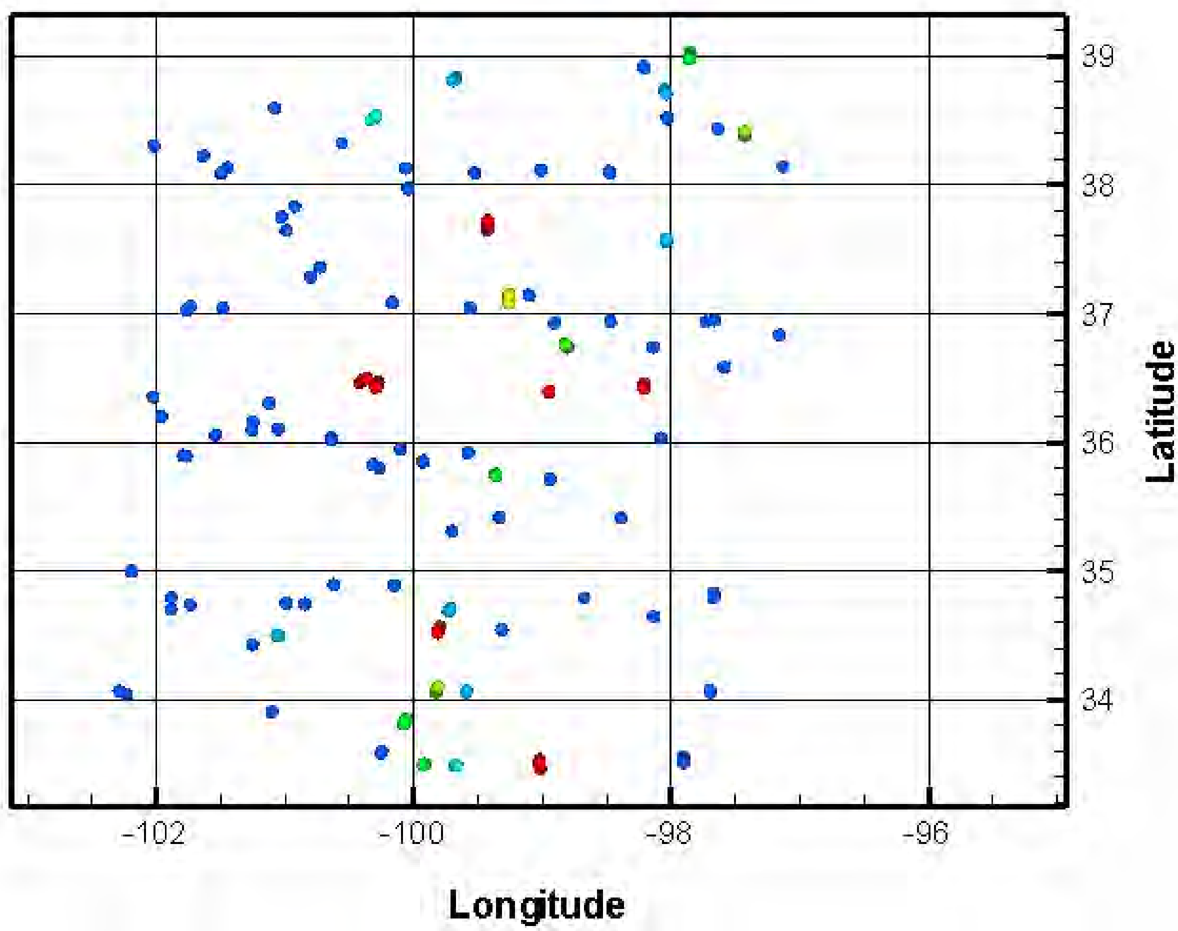
Lagrangian Particle Trajectories

Particle Position at 6 PM

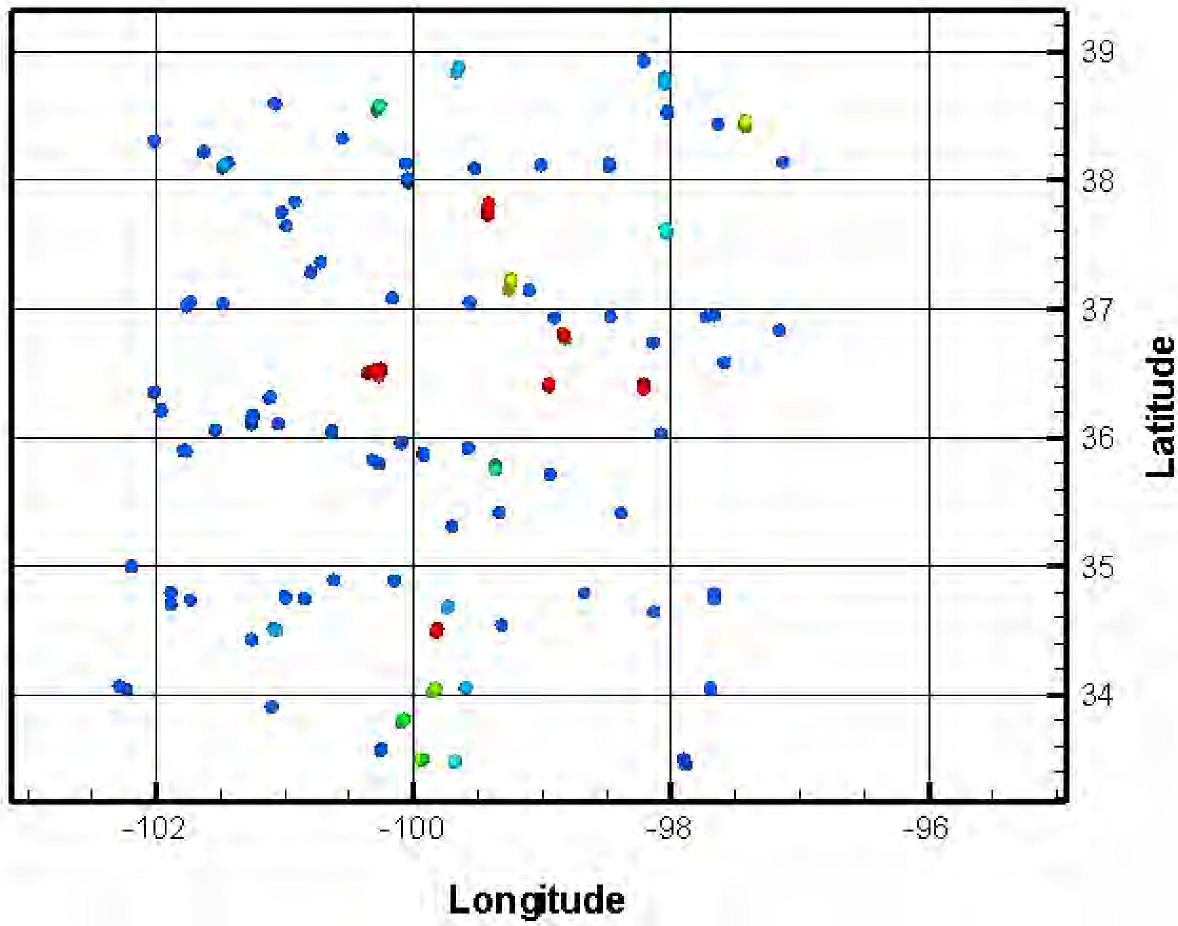
Colored by Height



Lagrangian Particle Trajectories

Particle Position at 7 PM

Colored by Height



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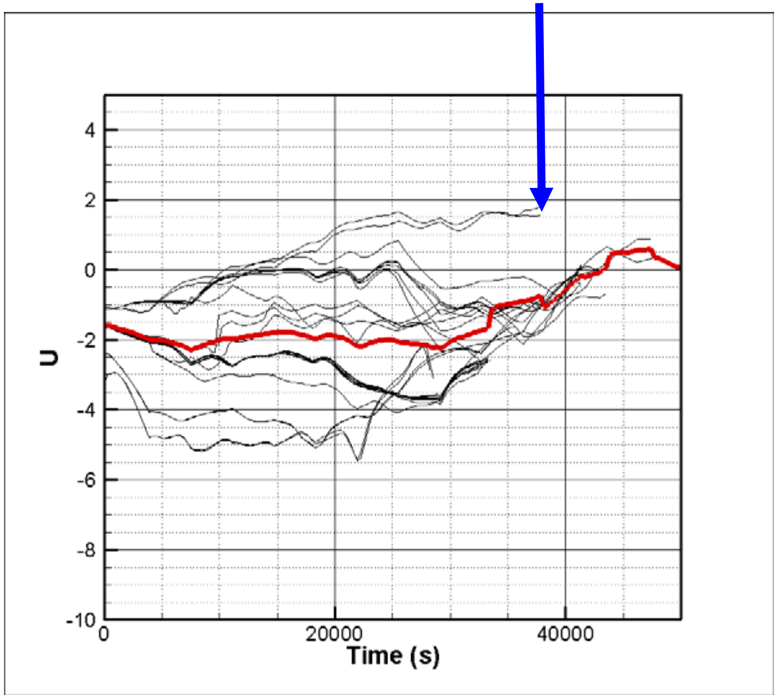
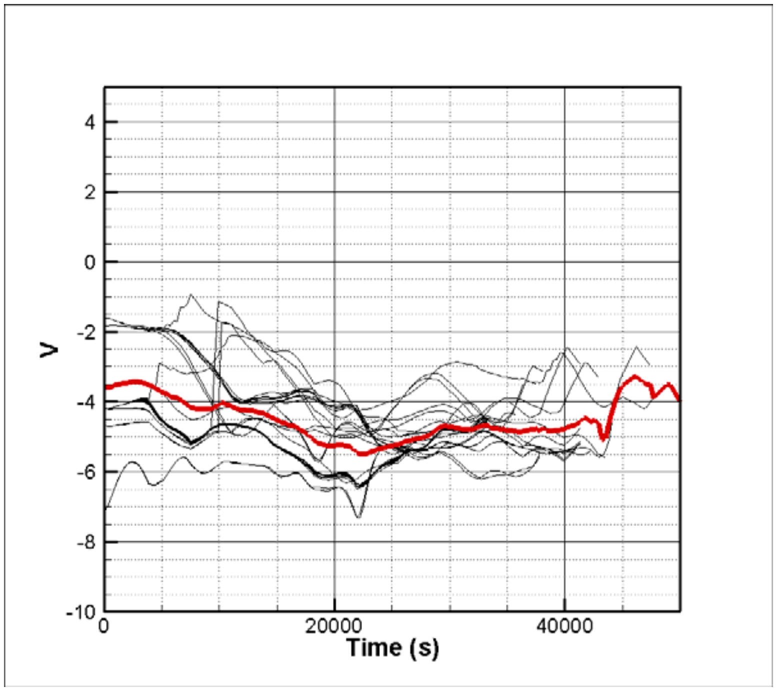
Lagrangian Particle Histories

Fewer members with increasing time





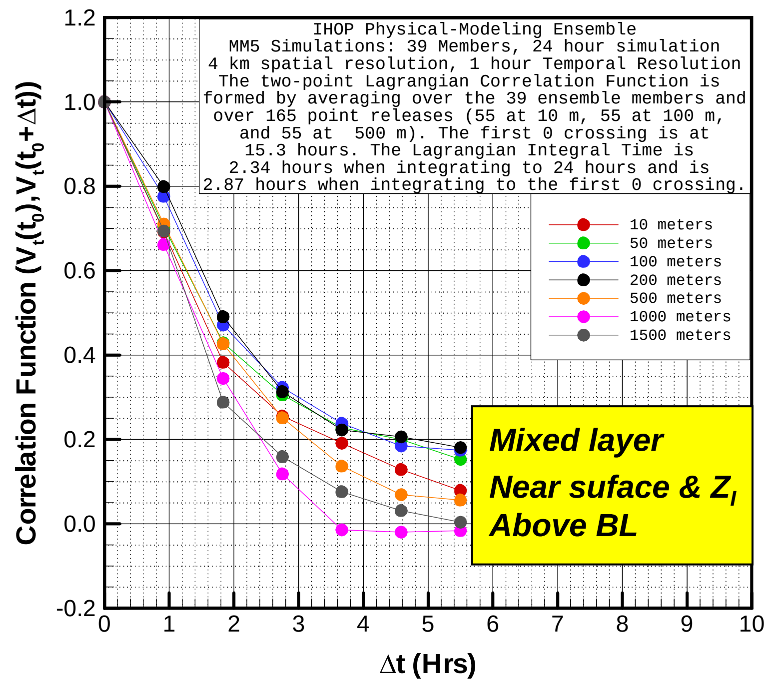
- Lagrangian Particle Data (Ensemble Members – black, Ensemble Mean – Red)

Lagrangian Particle Correlations

- The Lagrangian correlation functions were computed
  - Ensemble averaging for each release location and
  - Spatial averaging over release locations at the same height (to increase the sample contributing to the statistic)

Lateral Velocity Correlation Function

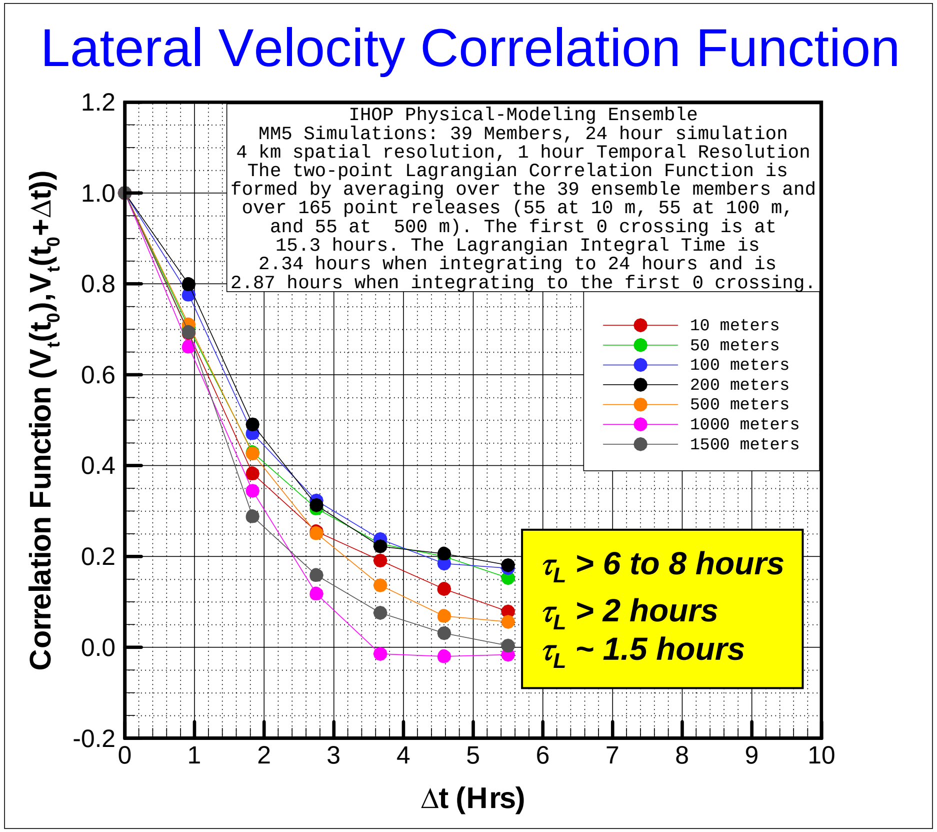
Particle release at 1 PM local time



Lagrangian Integral Times

- By extrapolating the correlation curve to 0 followed by integration, estimates for the Lagrangian Integral Time, τ_L, as a function of height can be computed:

These data indicate that τ_L is larger than 6-8 hours



IHOP Great Plains Model

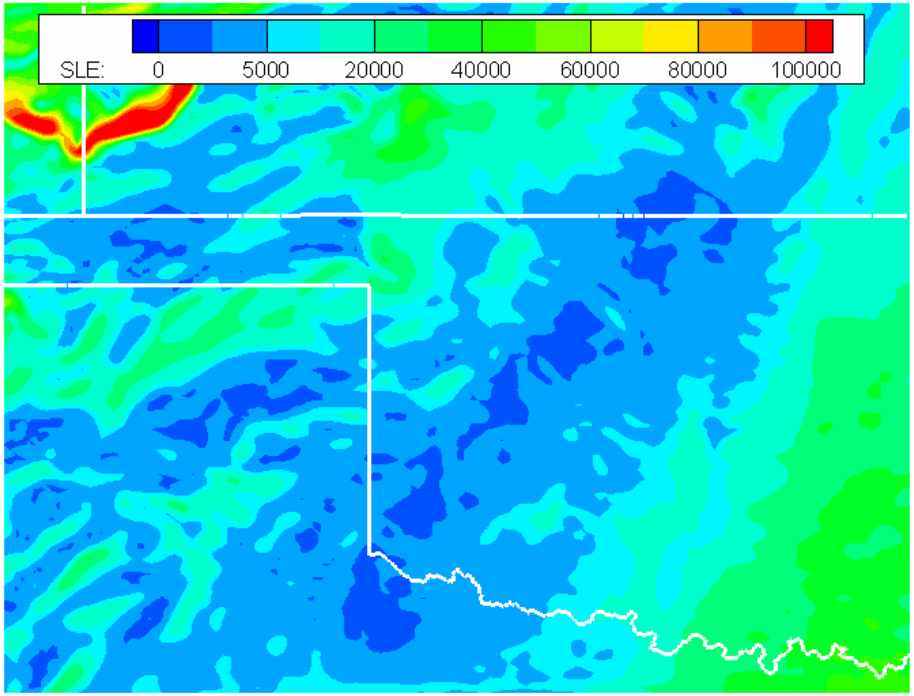
6 Hr C7F14 Release; 7 PM Local Time; 5/29/2002

- Using τ_L ~ *6-8 hours*, a field of SLE can be computed.
- The definition for SLE is a function of time and space.
- For this case,

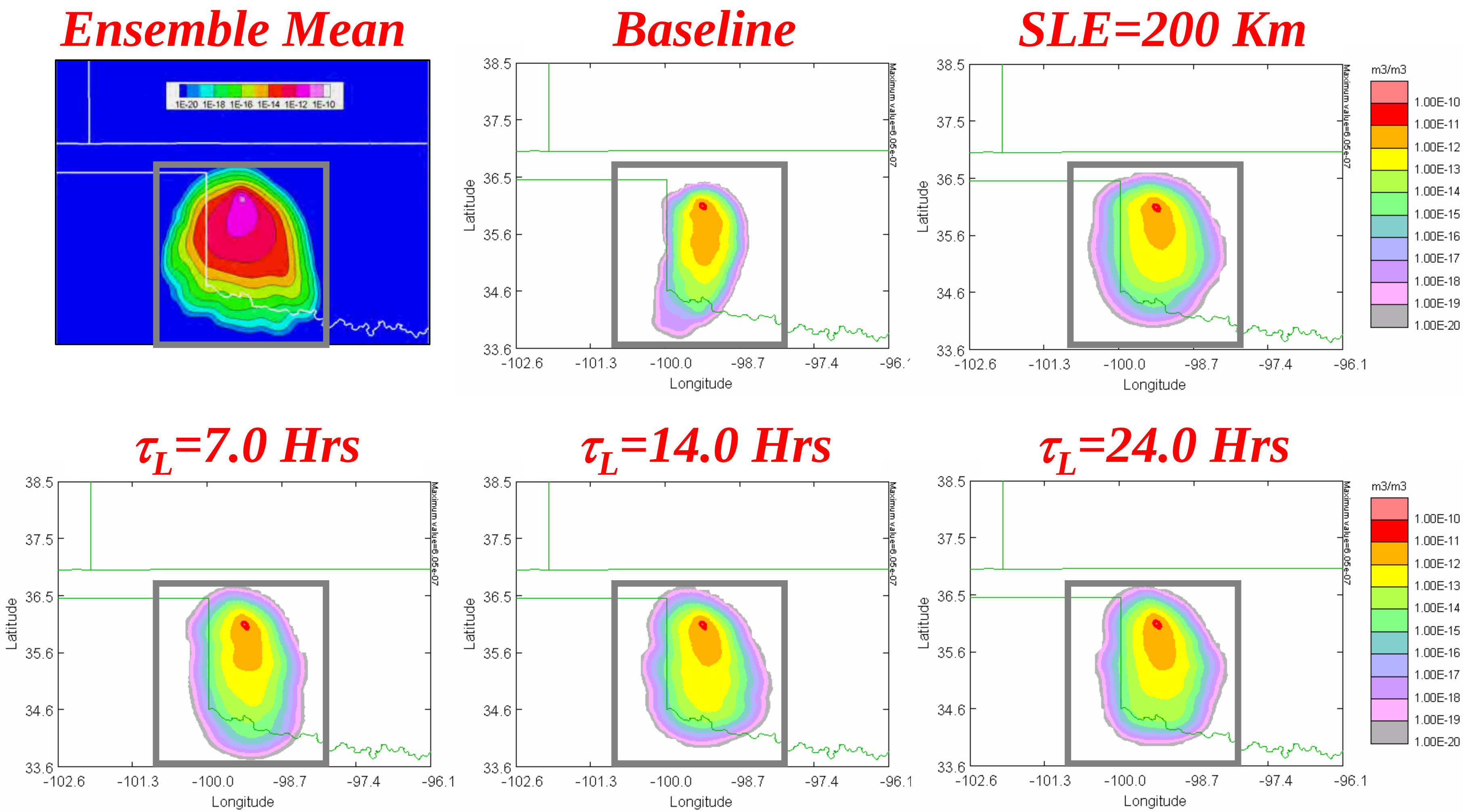
  0.0 km < SLE < 200 km

  large/small values depend on the local deviation velocities (on the uncertainty)

SLE



SCIPUFF (Hazard Mode)



Summary

- Taylor-dispersion arguments relate meteorological model variability to dispersion uncertainty
  - Modeling parameters depend on Eulerian ensemble deviation-velocity statistics and on the Lagrangian Integral Time
- Evaluation of the modeling parameters using a meteorological physics ensemble suggests
  - A Lagrangian Integral Time > 6 to 8 hours yielding SLE ranging from < 1 km to ~200 km under low wind & light rain
- Evaluation using SCIPUFF is ongoing.

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Continued Work

- Further evaluation of the ensemble variability modeling parameters for geometrically and meteorologically complicated cases
  - CAPTEX (Cross Appalachian Tracer Experiment) field experiment
  - NCEP's SREF ensemble with weather and topography
- Model the uncertainty parameters using these meteorological-ensemble-computed fields as "truth"
  - This project
  - 2-point spatial correlations (W. Kolczynski/D. Stauffer, PSU)

Institute for Defense Analyses

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2007 CBIS Conference
Renaissance Austin Hotel
Austin, Texas
8-12 January 2007

Evaluation of Urban HPAC Predictions with Joint Urban 2003 Field Trial Data

Nathan Platt
Steve Warner
Jeffry Urban
James Heagy

January 11, 2007

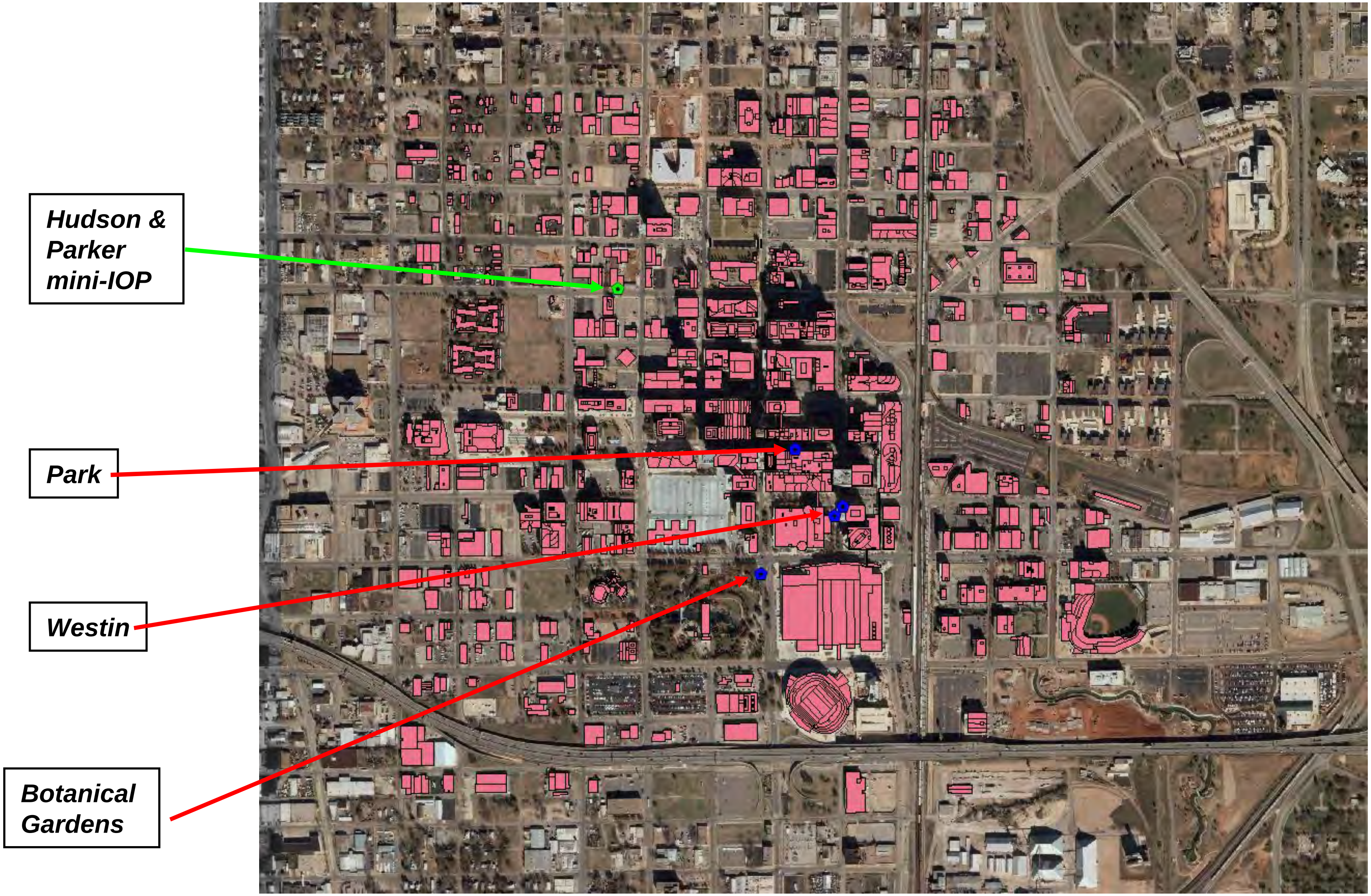
Outline

- Introduction
- Status
- Urban Mode / MET Comparisons
- Altitude MET “Thresholding”
- PROFILE ALL versus MEDOC meteorological input format

Introduction

- **Past IDA studies of Salt Lake City ("Urban 2000") & MUST**
- **Joint Urban 2003 field trial – a multi agency effort conducted in Oklahoma City during the summer of 2003**
  - For this study, we examined the outdoor SF_6 releases only
- **10 IOP's**
  - Continuous releases: **29**
  - Puff releases: 40
  - Additional mini-IOP on 7/15/05 to help understand vertical dispersion using crane samplers
- **Wealth of meteorological data**

JU2003 Downtown - Releases



ARL FRD CBD, Arcs

4km arc

2km arc

1km arc

Urban T&D Evaluation

- **Urban HPAC Configurations**
  - Baseline (UC)
  - UDM (DM)
  - UWM (WM)
  - UWM+UDM (DW)
  - Micro Swift/Spray (MS)

used in this presentation

- **Other Models**
  - MESO/RUSTIC (ITT)
    - » Models are obtained and we're learning how to run them
  - QUIC-URB/QUIC-PLUME (LANL)
    - » Models are obtained and we're learning how to run them

Status

- **To date, we have used over 50 separate MET input options to create HPAC predictions**
  - Some of these MET inputs were created for us by
    - » NCAR (RTFDDA, VLAS)
    - » NGIC (GCAT)
    - » DSTO-Australia (CCAM)
  - These include “low-altitude” MET thresholding for SODARs
- **Created over 2000 HPAC projects**
  - Developed “batching” capability to run multiple Urban HPAC projects without GUI
    - » Based in ICE
  - Total number of HPAC runs is well over 3000!
    - » Large number of projects were run more than once
      - MSS projects
      - SODARs and Profiler MET projects
- **Statistical and graphical evaluations near completion**

Joint Urban 2003
Separate MET Inputs to HPAC

Name	Description	Met Type	IOPs	Release	SMP time Interval	Mass Consistent Wind	Comment
BAS	Surrogate for DTRA met server OBS	sfc+prf	1-10	1-29	150	SWIFT	UC, DM, WM, DW, MS
BA1	**Surrogate for DTRA met server OBS**	**sfc+prf**	**1-10**	**1-29**	**150**	**SWIFT**	**WM, DW, MS**
BSS	Surrogate for DTRA met server OBS	sfc	1-10	1-29	150	SWIFT	UC, DM, WM, DW, MS
BSP	Surrogate for DTRA met server OBS	prf	1-10	1-29	150	SWIFT	UC, DM, WM, DW, MS
BRB	GCAT (PROFILE ALL)	gridded prf	1-10	1-29	150	SWIFT	UC, DM, WM, DW, MS
BR1	**GCAT (PROFILE ALL)**	**gridded prf**	**1-10**	**1-29**	**150**	**SWIFT**	**WM, DW**
GCM	GCAT Medoc format	MEDOC	1-10	1-29	150		UC, DM, WM, DW
PNS	PNNL cluster Sodar	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM, WM, DW, MS
PNP	PNNL cluster Profiler	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM, WM, DW, MS
PNA	PNNL cluster Sodar+Profiler (IOP01 has Sodar only)	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM, WM, DW, MS
P1A	**PNNL cluster Sodar+Profiler (IOP01 has Sodar only)**	**prf**	**2-10**	**3-29**	**150**	**MC-SCIPUFF**	**WM, DW**
SBG	Botanical Gardens mini-Sodar	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM, WM, DW, MS
ACS	ANL CC cluster Sodar	prf	1-2; 4-10	1-5; 9-29	150	MC-SCIPUFF	UC, DM, WM, DW, MS
ACP	ANL CC cluster Profiler	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM, WM, DW, MS
ACA	ANL CC cluster Sodar+Profiler (IOP03 has Profiler only)	prf	1-2; 4-10	1-5; 9-29	150	MC-SCIPUFF	UC, DM, WM, DW, MS
A1C	**ANL CC cluster Sodar+Profiler (IOP03 has Profiler only)**	**prf**	**1-2; 4-10**	**1-5; 9-29**	**150**	**MC-SCIPUFF**	**WM, DW**
PO1	Post Office, 10 sec met data	sfc	1-10	1-29	150	SWIFT	UC and DM only
PO2	Post Office, 5 min Central Scalar Averaging	sfc	1-10	1-29	150	SWIFT	UC and DM only
PO3	Post Office, 5 min Central Vector Averaging	sfc	1-10	1-29	150	SWIFT	UC and DM only
PO4	Post Office, 5 min interval, last 2 min Scalar Averaging	sfc	1-10	1-29	150	SWIFT	UC and DM only
PO5	Post Office, 5 min interval, last 2 min Vector Averaging	sfc	1-10	1-29	150	SWIFT	UC and DM only
PO6	Post Office, 15 min Central Scalar Averaging	sfc	1-10	1-29	150	SWIFT	UC and DM only
PO7	Post Office, 15 min Central Vector Averaging	sfc	1-10	1-29	150	SWIFT	UC, DM, WM, DW, MS
P7A	**Post Office, 15 min Central Vector Averaging**	**sfc**	**1-10**	**1-29**	**150**	**SWIFT**	**WM, DW, MS**
PO8	Post Office, 15 min interval, last 2 min Scalar Averaging	sfc	1-10	1-29	150	SWIFT	UC and DM only
PO9	**Post Office, 15 min interval, last 2 min Vector Averaging**	**sfc**	**1-10**	**1-29**	**150**	SWIFT	**Problem with IOP_02_DM**
C01	CCAM (1 km)	MEDOC	1-10	1-29	150		UC, DM, WM, DW
C08	CCAM (8 km)	MEDOC	1-10	1-29	150		UC, DM, WM, DW
C60	CCAM (60 km)	MEDOC	1-10	1-29	150		UC, DM, WM, DW
SB1	Botanical Gardens mini-Sodar, Cutoff Alt = 30 m	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM
SB2	Botanical Gardens mini-Sodar, Cutoff Alt = 50 m	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM
SB3	Botanical Gardens mini-Sodar, Cutoff Alt = 70 m	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM
PS2	PNNL cluster Sodar, Cutoff Alt = 50 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
PS3	PNNL cluster Sodar, Cutoff Alt = 70 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
PS4	PNNL cluster Sodar, Cutoff Alt = 100 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
PS5	PNNL cluster Sodar, Cutoff Alt = 150 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
PS6	PNNL cluster Sodar, Cutoff Alt = 250 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
PS7	PNNL cluster Sodar, Cutoff Alt = 350 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
AS1	ANL CC cluster Sodar, Cutoff Alt = 30 m	prf	1-2; 4-10	1-5; 9-29	150	MC-SCIPUFF	UC, DM
AS2	ANL CC cluster Sodar, Cutoff Alt = 50 m	prf	1-2; 4-10	1-5; 9-29	150	MC-SCIPUFF	UC, DM
AS3	ANL CC cluster Sodar, Cutoff Alt = 70 m	prf	1-2; 4-10	1-5; 9-29	150	MC-SCIPUFF	UC, DM
AS4	ANL CC cluster Sodar, Cutoff Alt = 100 m	prf	1-2; 4-10	1-5; 9-29	150	MC-SCIPUFF	UC, DM
CRA	Crane 10-minute vector avergaed sonics data	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
CR1	Crane sonics, Cutoff Alt = 30 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
CR2	Crane sonics, Cutoff Alt = 50 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
CR3	Crane sonics, Cutoff Alt = 70 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
DPG	DPG mini-Sodar	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
DP0	DPG mini-Sodar, Cutoff Alt = 15 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
DP1	DPG mini-Sodar, Cutoff Alt = 30 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
DP2	DPG mini-Sodar, Cutoff Alt = 50 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
DP3	DPG mini-Sodar, Cutoff Alt = 70 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
DP4	DPG mini-Sodar, Cutoff Alt = 100 m	prf	1-10	1-29	150	MC-SCIPUFF	UC, DM
FRD	FRD Sodar	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM
FR2	FRD mini-Sodar, Cutoff Alt = 50 m	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM
FR3	FRD mini-Sodar, Cutoff Alt = 70 m	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM
FR4	FRD mini-Sodar, Cutoff Alt = 100 m	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM
FR5	FRD mini-Sodar, Cutoff Alt = 150 m	prf	2-10	3-29	150	MC-SCIPUFF	UC, DM

SWIFT, MC-SCIPUFF Processed MET and MEDOC Formatted MET

- **For MET input options that involve inputs that SWIFT was originally designed for, we used SWIFT to obtain mass consistent winds**
  - "DTRA Server MET" like inputs
    - » Surface station(s) .SFC and Upper Air profile(s) .PRF
  - Regularly spatio-temporally gridded data
    - » Forecasts by MM5
    - » These include GCAT "PROFILE ALL" and RTFFDA from NCAR

- **For MET input options that use JU2003 wind-profile instruments, we used MC-SCIPUFF to obtain mass consistent winds**
  - Profilers
  - (mini) Sodars
  - Crane Sonics
    - » It is possible that Crane Sonics would be compatible with SWIFT, but then results would be incompatible with SODARs

- **For MET input options that would use LIDAR data, we plan to use SWIFT**
  - Running of NCAR's VLAS outputs on IOP 2 seems to confirm this

- **CCAM MET (DSTO-Australia) is available only in MEDOC format**
  - Obtained and run GCAT MEDOC formatted MET predictions for comparisons with CCAM

- **This leads to a caution when comparing different MET options**

Urban Mode / MET Comparisons
Notation for MET Input Options

- **ACA: ANL (downwind) Sodar + Profiler**
- **PNA: PNNL (upwind) Sodar + Profiler**
- **PO7: Post Office rooftop station**
- **BAS: Baseline (airport) Surface + Profiler**
- **BRB: GCAT "Profile All"**
- **SBG: Botanical Gardens mini-Sodar**

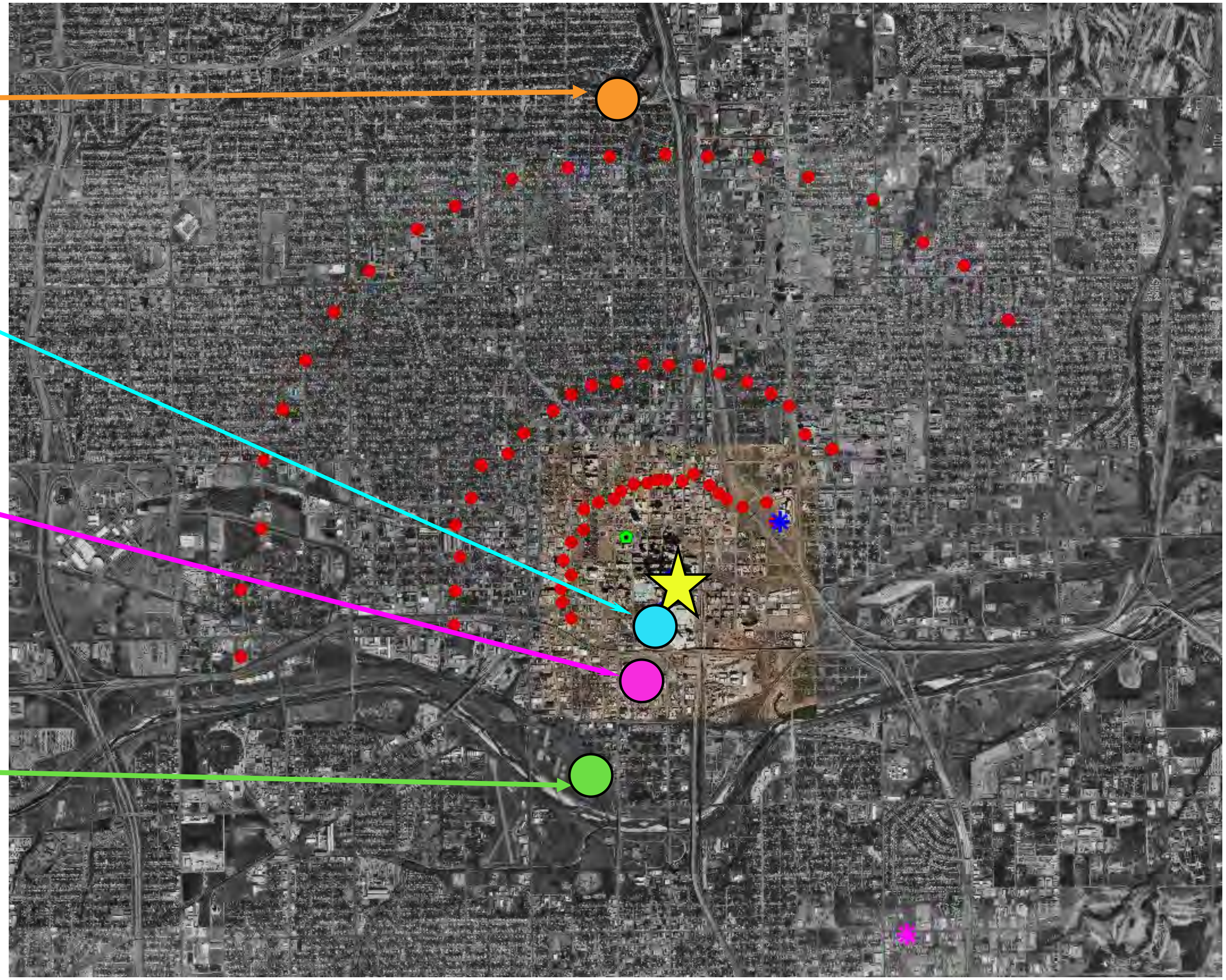
JU 2003 MET Stations: PNNL, ANL Clusters, Post Office Rooftop, & Botanical Gardens

ANL (CC)
Radiosonde
Profiler/RASS
Mini-Sodar

BG Mini-Sodar

Post Office Rooftop

PNNL
Radiosonde
Profiler/RASS
Sodar



Baseline MET
Within 30km of Releases

- **Surface**
  - Source: University of Utah Mesonet (MesoWest)
    - » Stations: KOUN, KOKC, KPWA, KTIK
- **Upper Air**
  - Source: University of Wyoming
  - Station: KOUN

Red – Surface
Blue – Profile
Black - Releases

Prevailing wind speed is from South

Standard Statistics and 2D Measures of Effectiveness

- **Calculated stats (13 types) and 2D MOEs for 30-min average concentrations for all available ARL FRD samplers**
- **Considered 29 continuous releases (10 IOPs)**
- **Stats and MOEs calculated for each 2-hr observation period, then averaged over releases**
  - Separate averages for day and night releases
- **MOE: 250 ppt threshold "hazard area"**
- **Stats for this discussion:**

$$NAD = \frac{\sum_i \left| C_p^{(i)} - C_o^{(i)} \right|}{\sum_i \left(C_p^{(i)} + C_o^{(i)} \right)}$$

$$FB = \frac{\sum_i \left(C_p^{(i)} - C_o^{(i)} \right)}{0.5 \sum_i \left(C_p^{(i)} + C_o^{(i)} \right)}$$

Comparisons done for:

1) *day/night*
2) *all surface samplers, CBD, all arcs, each arc*
3) *each of eight 15-minute periods, each of four 30-minute periods, each of two 1-hour periods, all 30-minute periods , and all 2-hour periods*
4) *In total, ~82,000 metrics computed*

Results

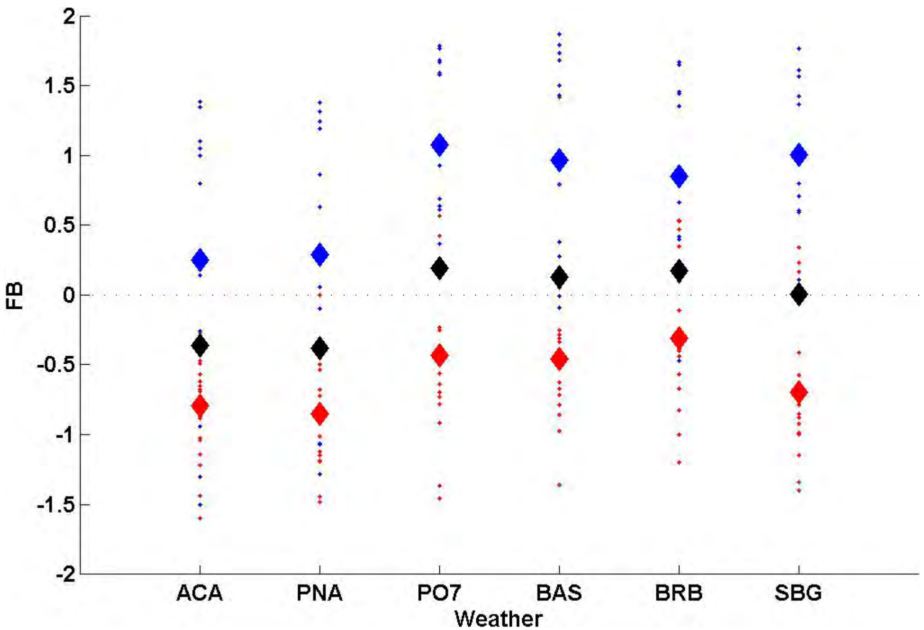
- **Night vs. Day discrepancy for UC, UDM, UWM, UDM+UDW modes**
  - Significant differences in model performance depending on time of day
  - Daytime performance is better than nighttime for MET input options with a large day – night discrepancy (Baseline, GCAT, PO, BG)
    - » For small discrepancies (ANL, PNNL): night slightly better than day
  - UC, UDM, UWM, and UDM+UDW all tend to under-predict during the day and over-predict at night (across nearly all MET input options)

- **Little day – night discrepancy for MSS mode**
  - MSS tends to over-predict during both day and night
  - MSS day and night results are similar (neither has clearly better results)

- **Model performance**
  - Daytime model performance difficult to rank
  - UDM performs better than UC at night for PNA, Baseline, GCAT, BG
  - MSS performs better than UC at night for PO, Baseline, BG
  - MSS has less prediction bias than UC, UDM at night for PO, Baseline, GCAT
    - » During the day, bias is also small (comparable to UDM+UDW with the opposite sign)
  - UWM does not appear to enhance performance over UDM

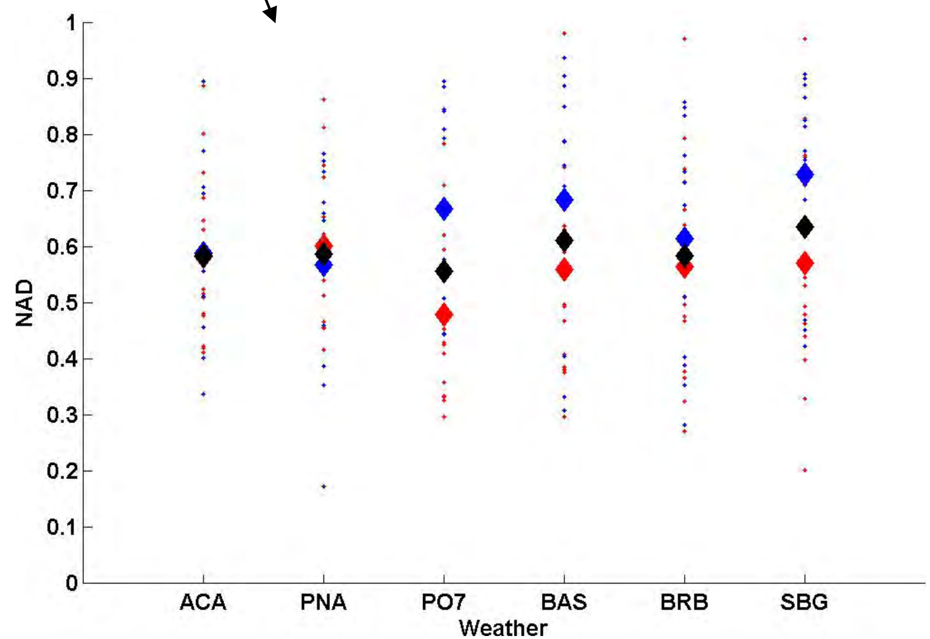
- **MET input options**
  - Post Office, GCAT, Baseline met perform slightly better than ANL and PNNL MET during the day but over-predict worse at night for UC, UDM, UWM, UDM+UDW
  - ANL MET seems to be the best overall performer at night (small margin)
  - PO MET seems to be the best overall performer during the day (small margin)
  - Botanical Gardens mini-Sodar is the worst performer at night

FB and NAD for UDM Mode



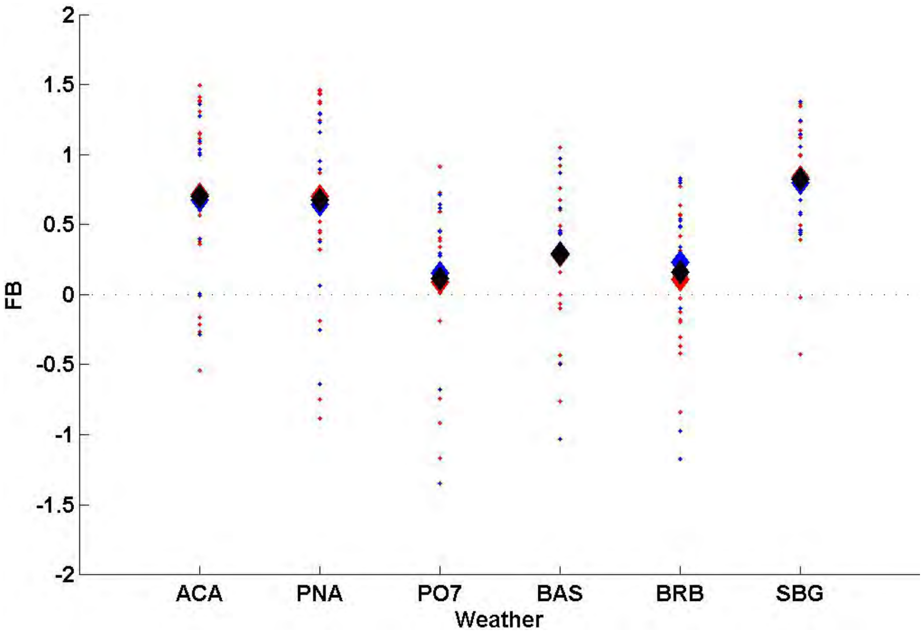
FB

NAD



- all
- night
- day

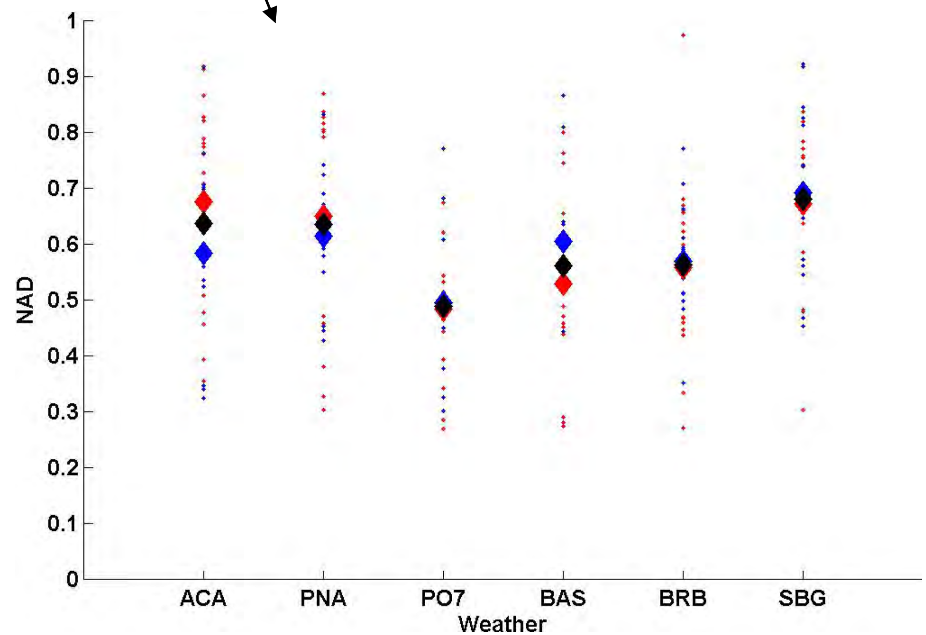
FB and NAD for MSS Mode



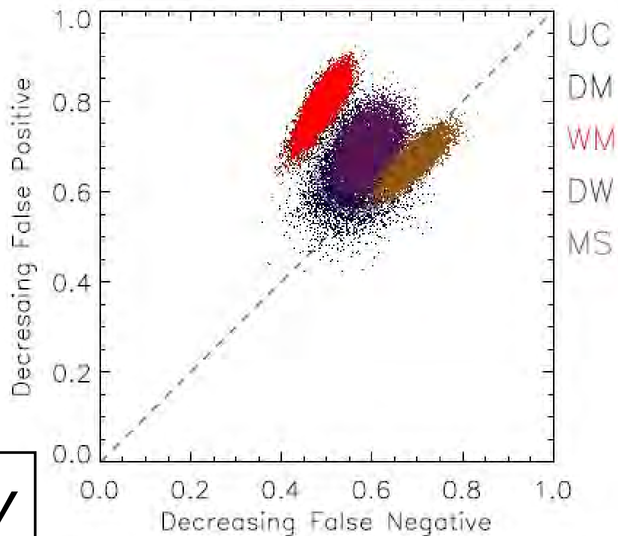
FB

all
night
day

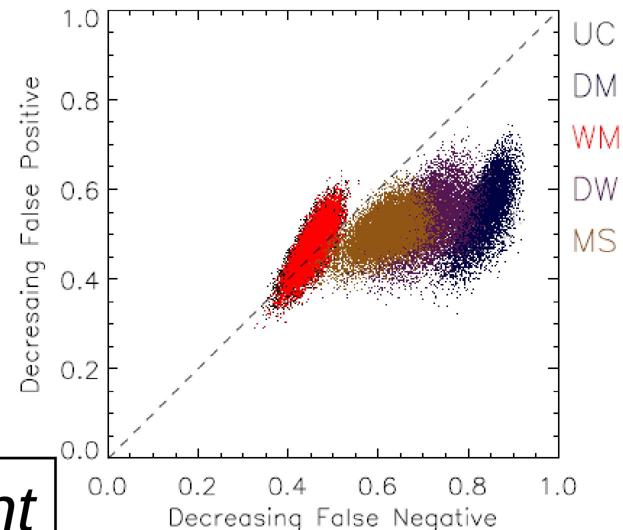
NAD



MOE Values (30 minute): Average Concentration and 250 ppt Threshold (for Baseline MET Input Option)

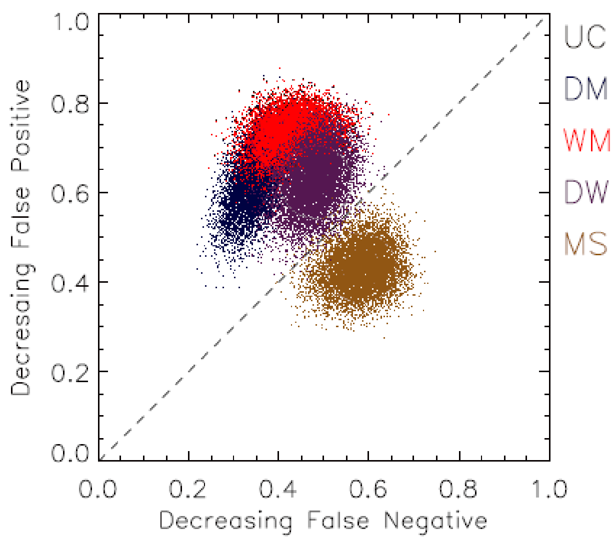


250 ppt threshold

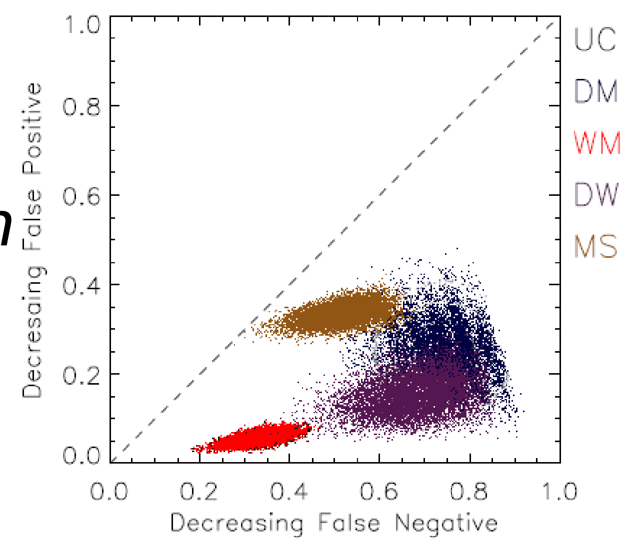


Day

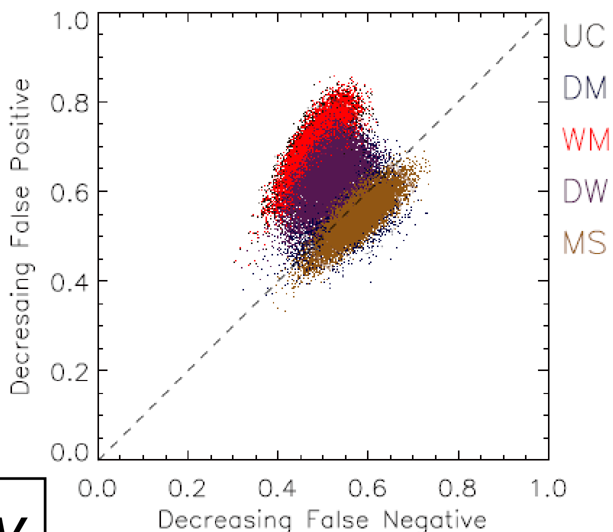
Night



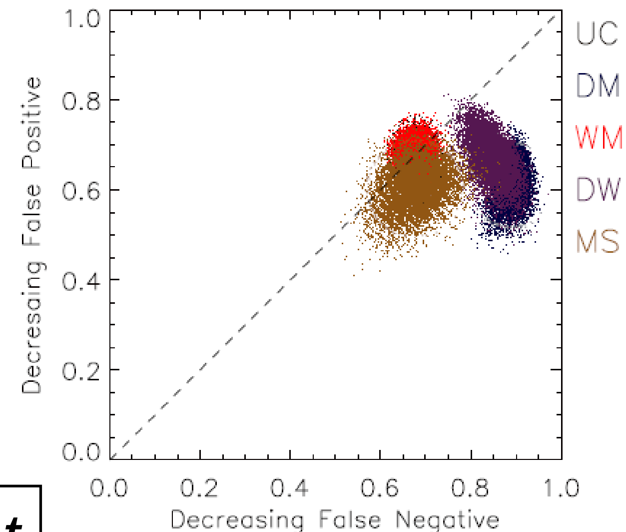
average concentration



MOE Values (30 minute): Average Concentration and 250 ppt Threshold (for GCAT MET Input Option)

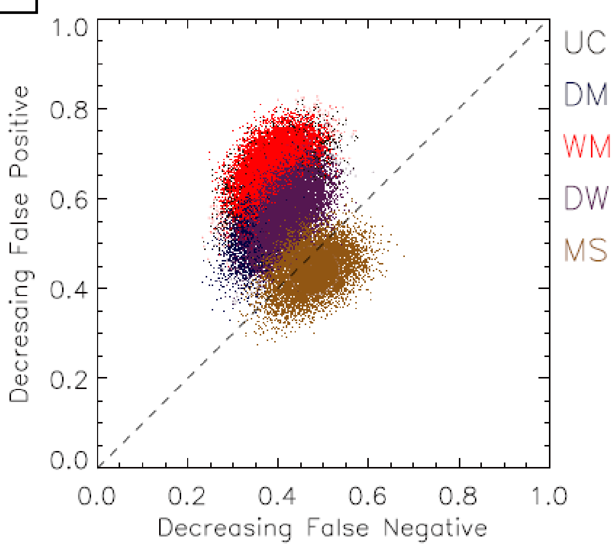


250 ppt threshold

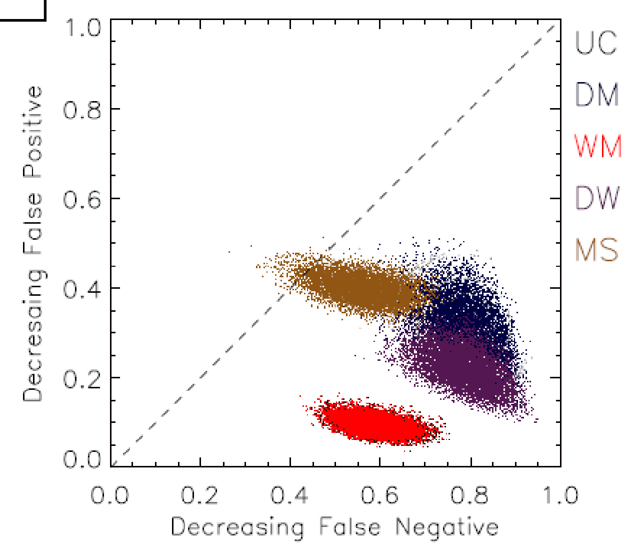


Day

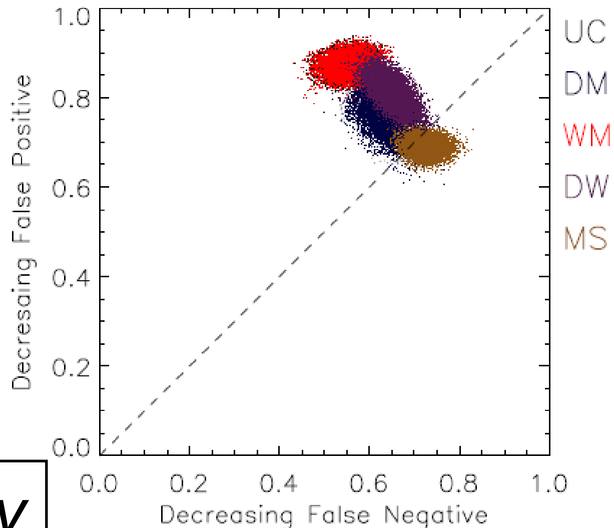
Night



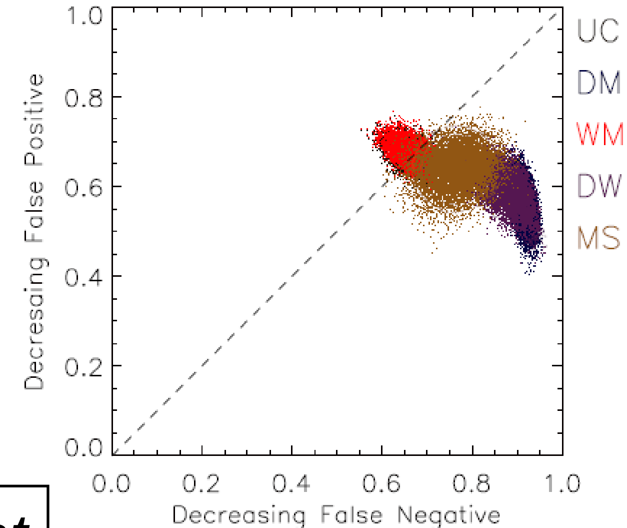
average concentration



MOE Values (30 minute): Average Concentration and 250 ppt Threshold (for Post Office MET Input Option)

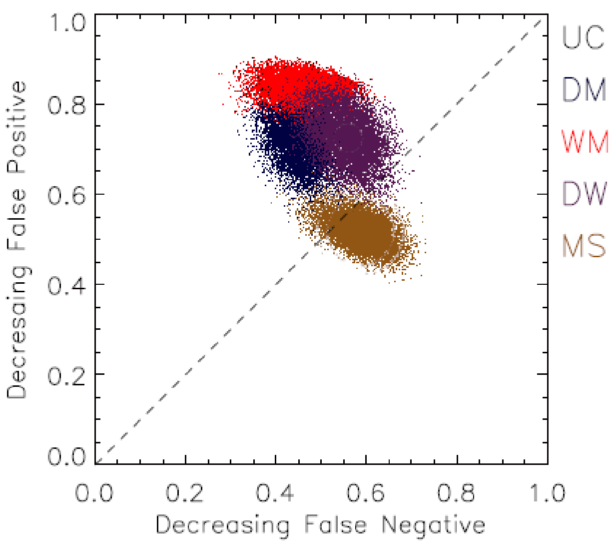


250 ppt threshold

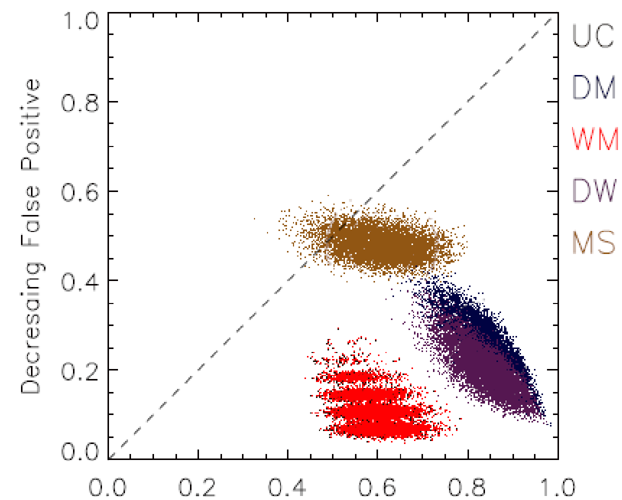


Day

Night



average concentration

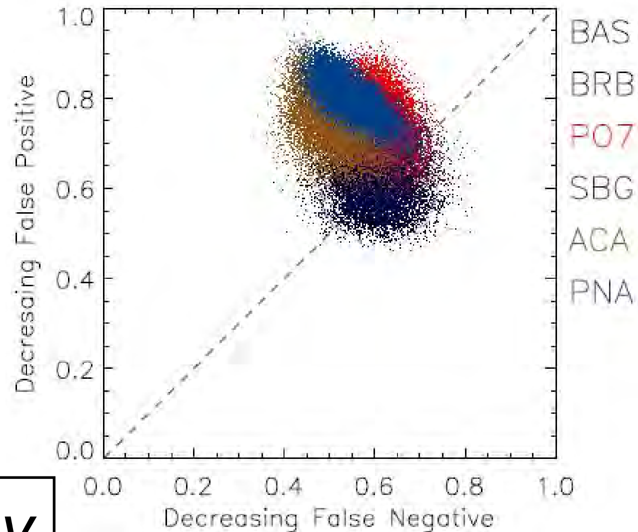


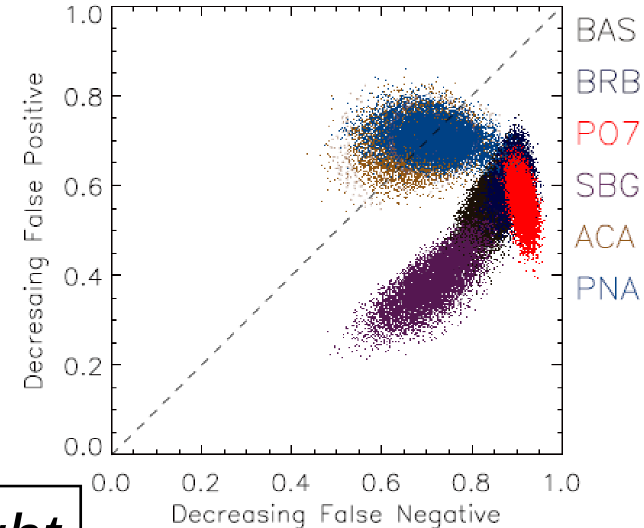
MOE Values (30 minute): Average Concentration and 250 ppt Threshold (for UDM mode)

Day

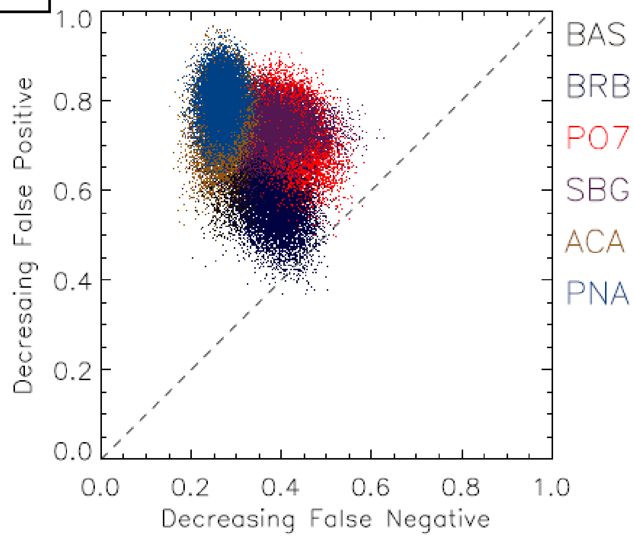
Night

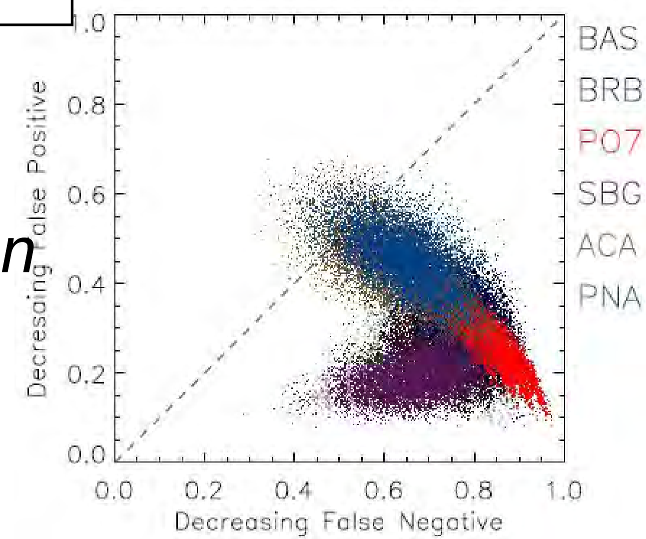
250 ppt threshold



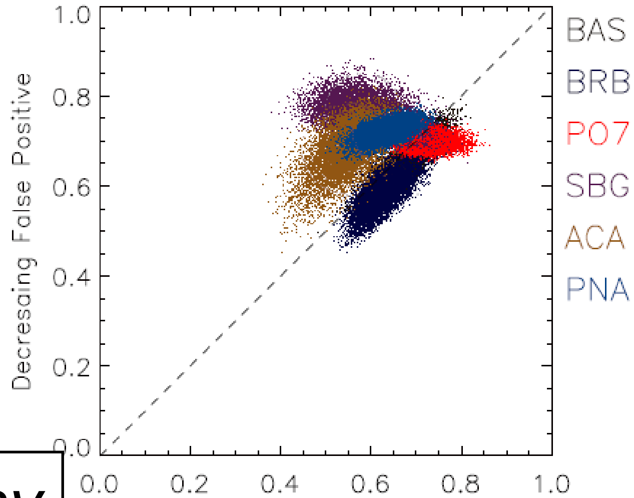


average concentration

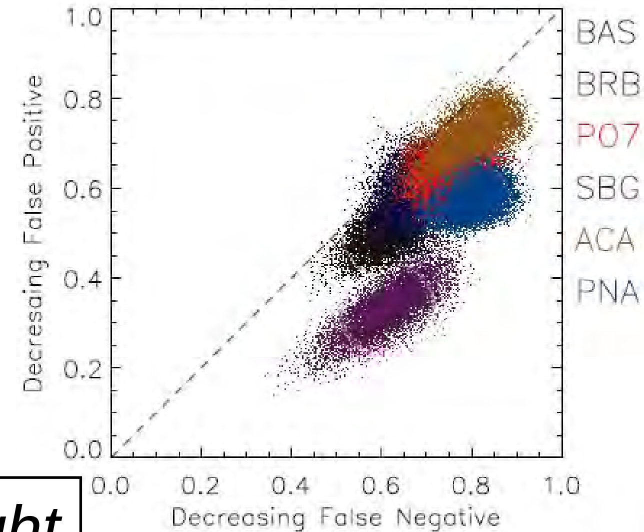




MOE Values (30 minute): Average Concentration and 250 ppt Threshold (for MSS mode)

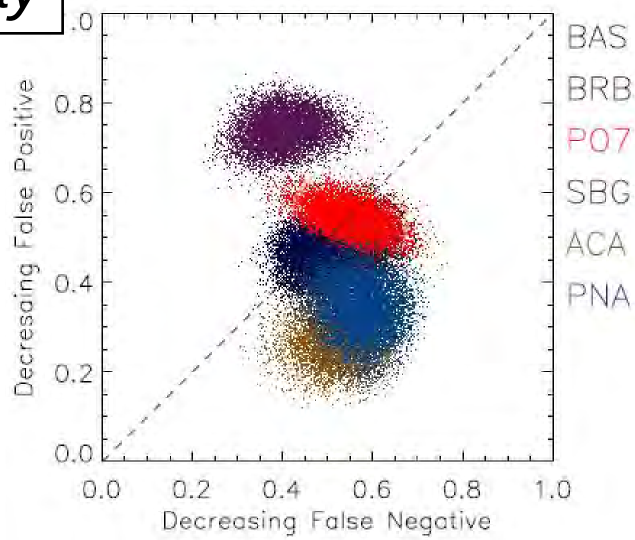


250 ppt threshold

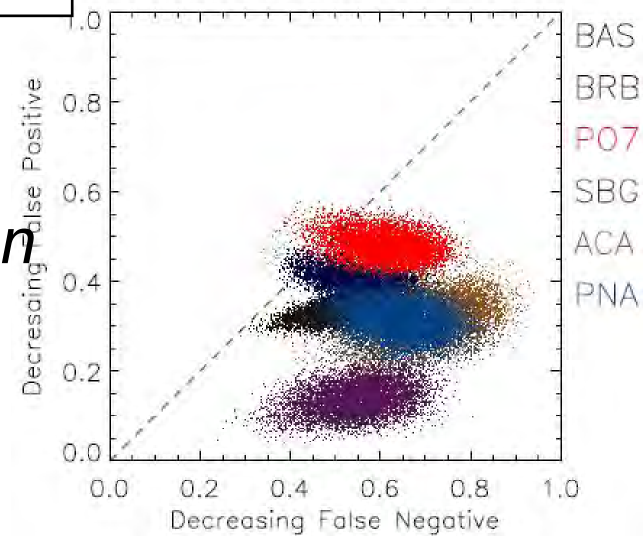


Day

Night



average concentration



Results

- **Night vs. Day discrepancy for UC, UDM, UWM, UDM+UDW modes**
  - Significant differences in model performance depending on time of day
  - Daytime performance is better than nighttime for MET input options with a large day – night discrepancy (Baseline, GCAT, PO, BG)
    - » For small discrepancies (ANL, PNNL): night slightly better than day?
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  - MSS tends to overpredict during both day and night
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  - Daytime model performance difficult to rank
  - UDM performs better than UC at night for PNA, Baseline, GCAT, BG
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  - MSS has less prediction bias than UC, UDM at night for PO, Baseline, GCAT
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- **Met inputs**
  - Post Office, GCAT, Baseline met perform slightly better than ANL and PNNL MET during the day but overpredict worse at night for UC, UDM, UWM, UDM+UDW
  - ANL MET seems to be the best overall performer at night (small margin)
  - PO MET seems to be the best overall performer during the day (small margin)
  - Botanical Gardens mini-Sodar is the worst performer at night

Altitude Met Thresholding

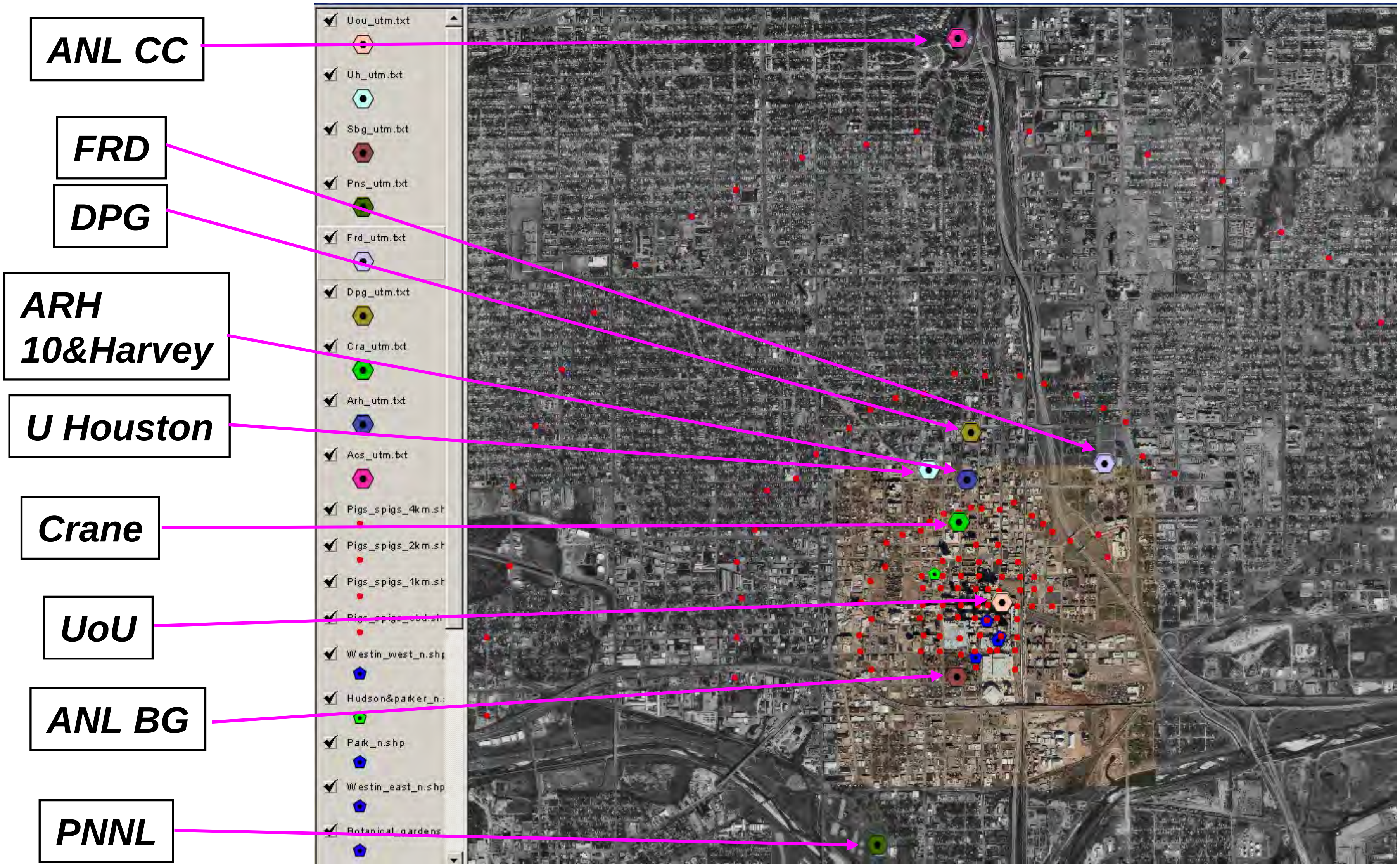
Wind Measurements Within Urban Canopy and Its Effects on HPAC Predictions

- **Intuitively, to obtain better hazard predictions, one would like to measure meteorology as close as possible to the release location**
  - In terms of urban releases, this leads to the suggestion to use wind measurements that include altitudes that are within the urban canopy
    - » Rooftop measurement from the tallest building
      - LDS building in Salt Lake City field trials
    - » (mini) Sodar located within City
      - Botanical Gardens mini-Sodar in JU2003

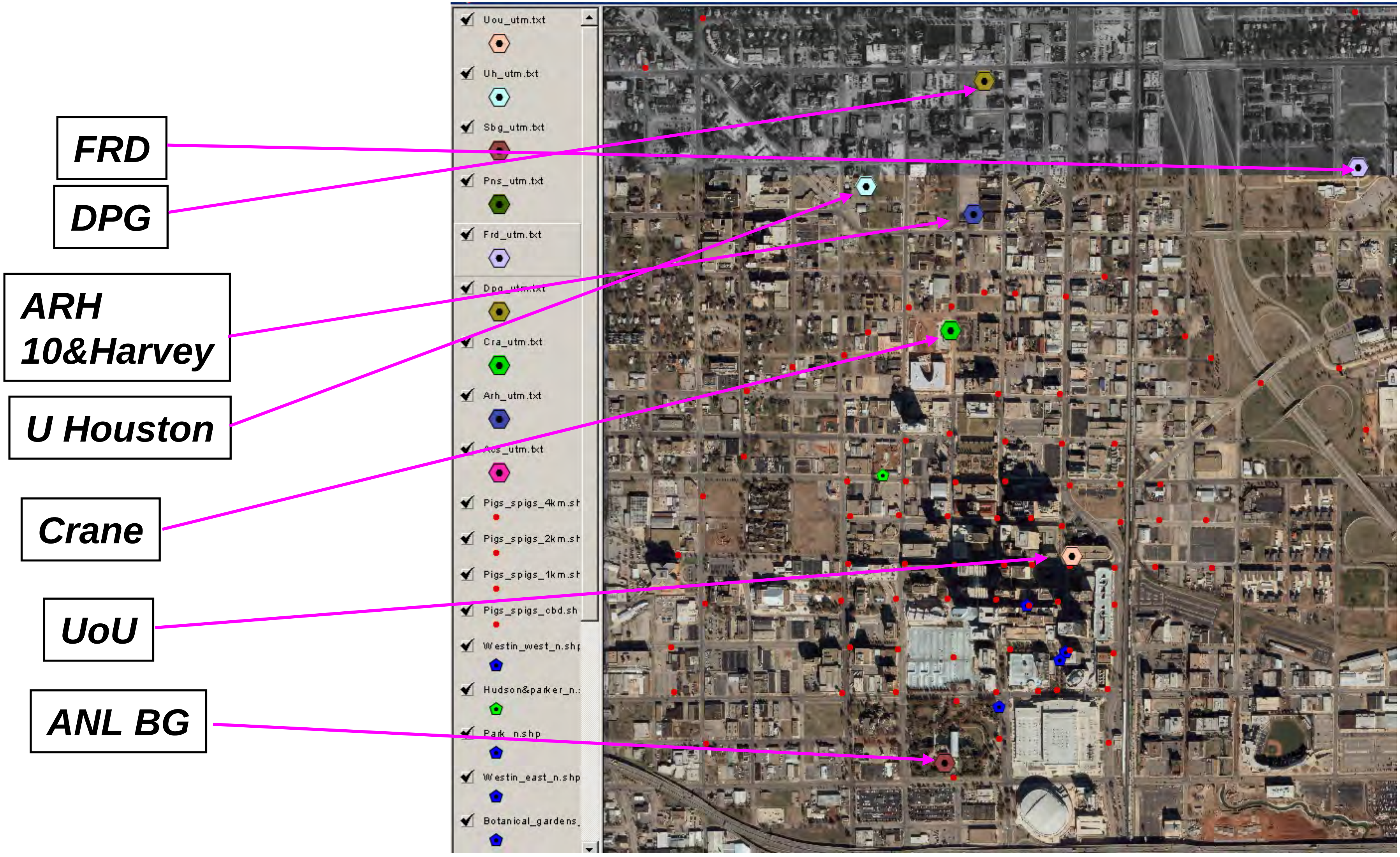
- **We have somewhat contradictory results from SLC and MUST studies**
  - LDS MET in SLC performed **worst** in terms of predicting potential hazards
    - » Most likely reason is that there were too much (non-representative) fluctuation in the wind direction
  - Sonic MET at 16 meters in MUST performed **best**
    - » 16 meters is ~ 6 times higher than the height of the shipping containers, and thus most likely samples "unperturbed" flow

- **How will this affect SODARs in JU2003**
  - **Some of the measurements are within the urban canopy**

JU2003 FRD Samplers, (mini) Sodars and Crane



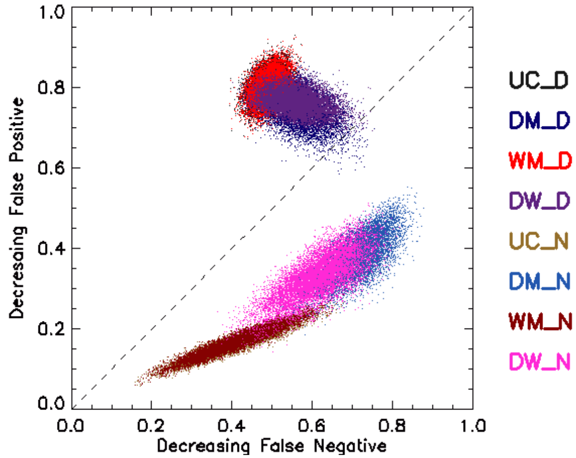
JU2003 FRD Samplers, (mini) Sodars and Crane Downtown Region



ANL BG and PNNL (mini) Sodar MOE Plots

Botanical Gardens mini-Sodar

PNNL Sodar



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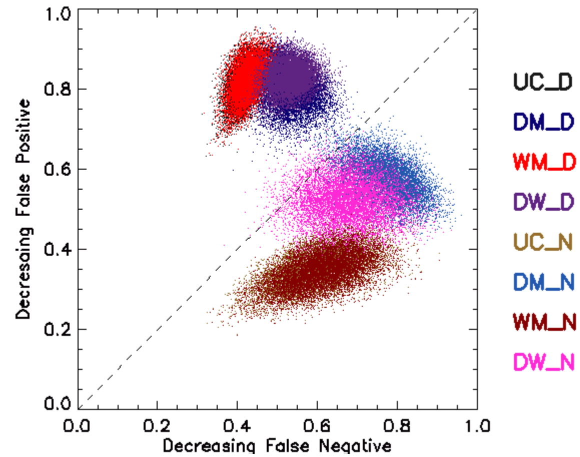
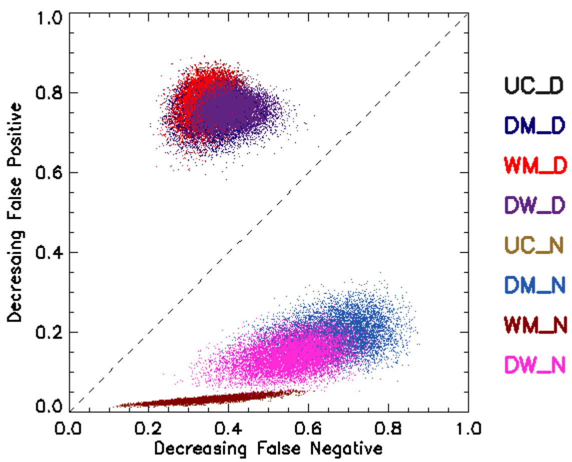
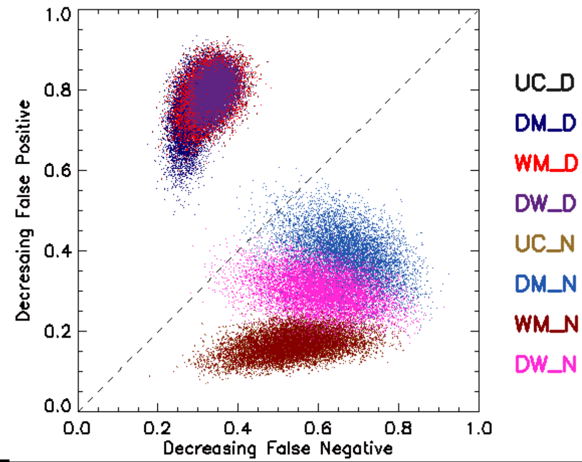


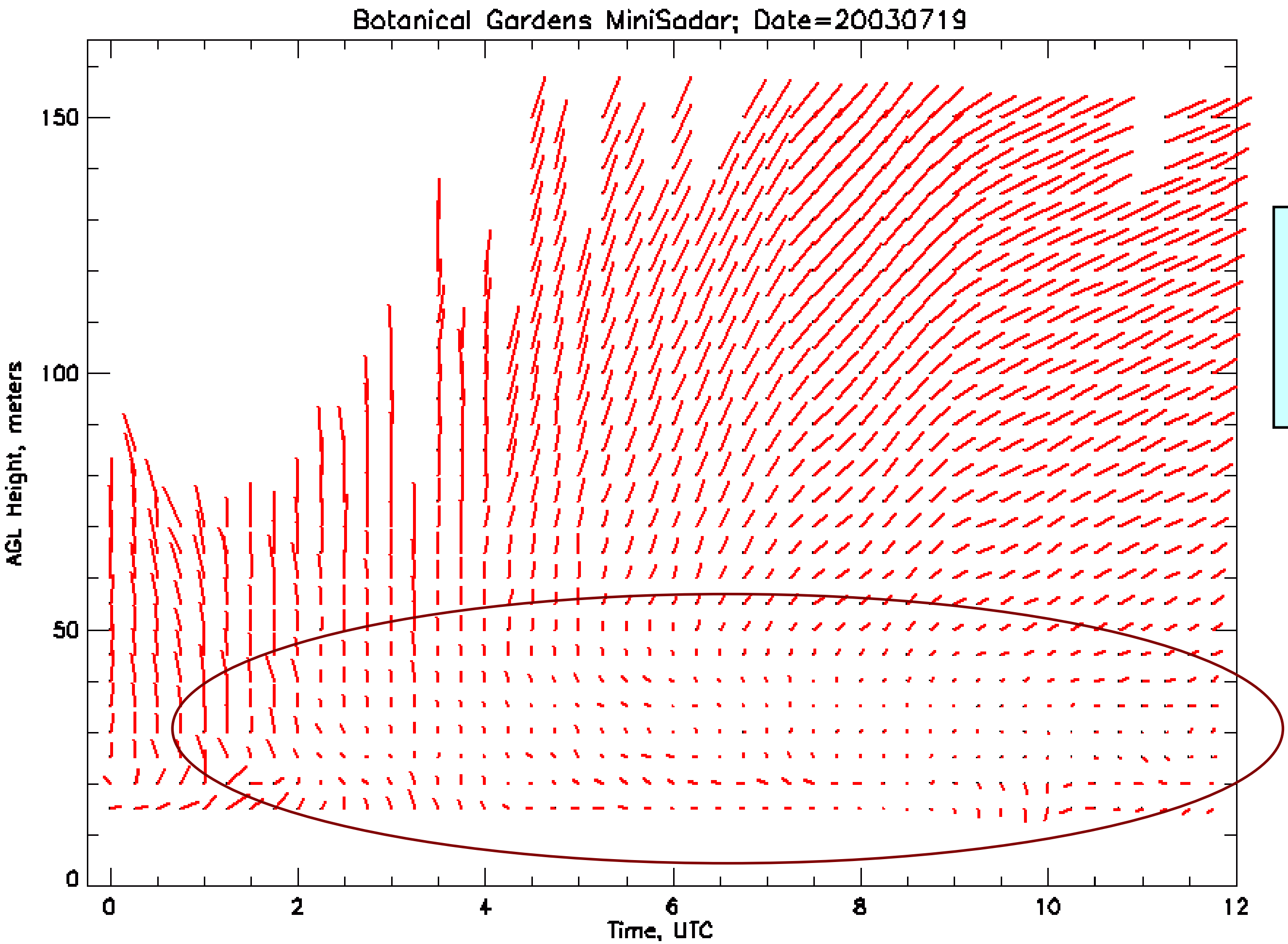


average concentration



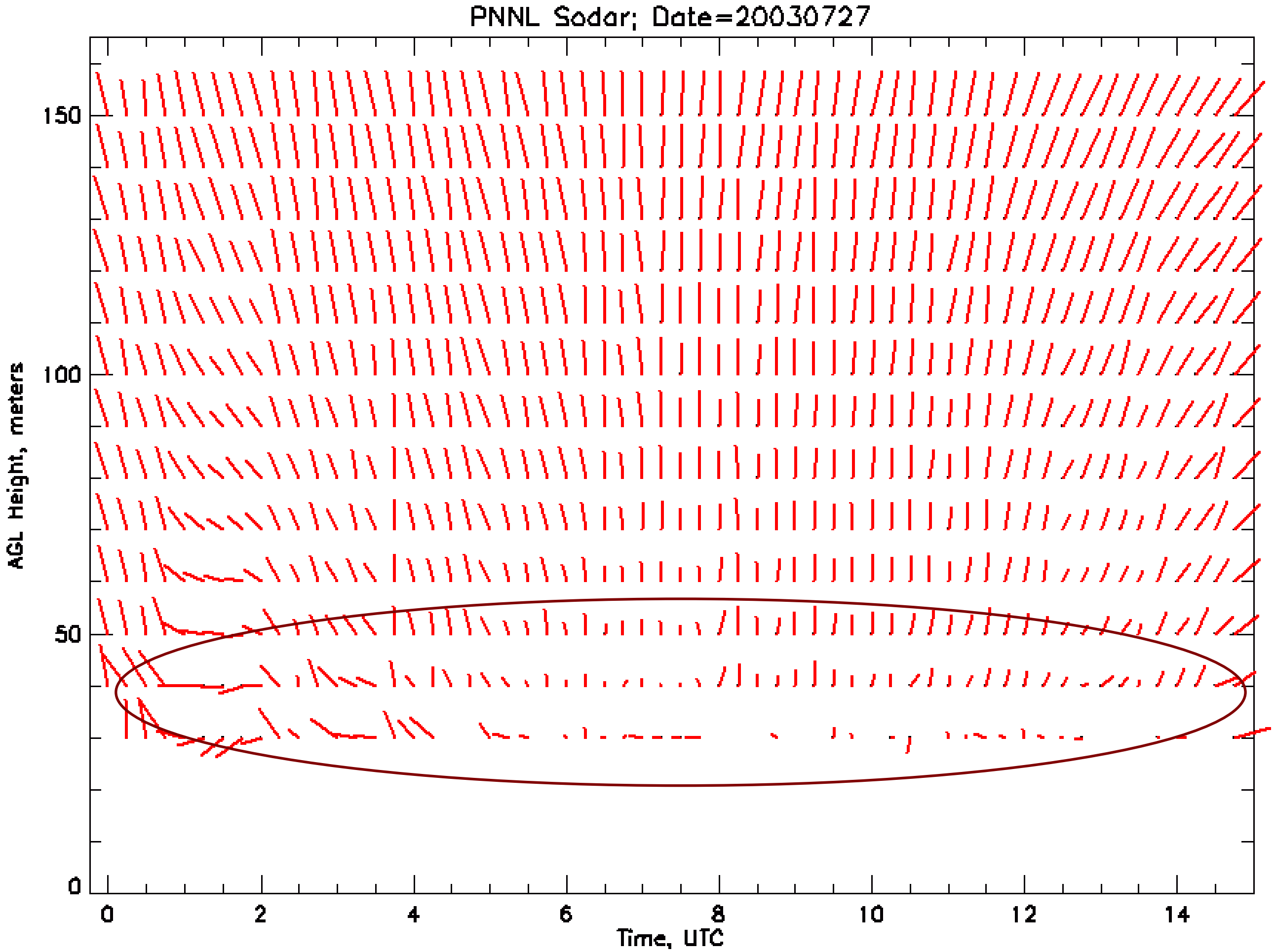
Differences between night and day predictions / Night results seems to be significantly degraded with respect to day predictions

ANL BG mini-Sodar Profiles



At night, low altitude winds are significantly different from higher altitude

PNNL Sodar Profiles



At night, low altitude winds are significantly different from higher altitude

Consider effects on URBAN HPAC predictions by removing low lever wind vectors

Rules of the Game
Notation Key

- Run URBAN HPAC predictions for all (mini) Sodars
  - Urban Canopy (UC) and UDM (DM)
  - Vary cut-off altitude below which wind is ignored
  - Calculate MOE
    - » Night, Day
    - » 250 ppt exceedance threshold, average concentrations (based on 30-minute interval)

Notation Key

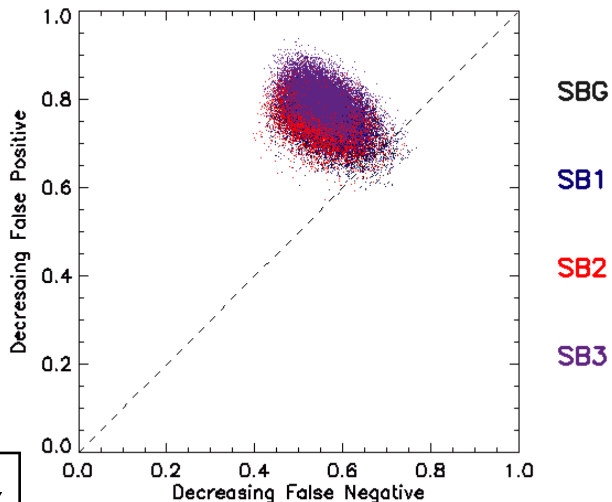
Third Character in Name	Example	Cut-Off Altitude, meters	Sodar
0	DP0	15	Dugway
1	DP1	30	Dugway
2	PS2	50	PNNL
3	PS3	70	PNNL
4	PS4	100	PNNL
5	PS5	150	PNNL
6	PS6	250	PNNL
7	PS7	350	PNNL

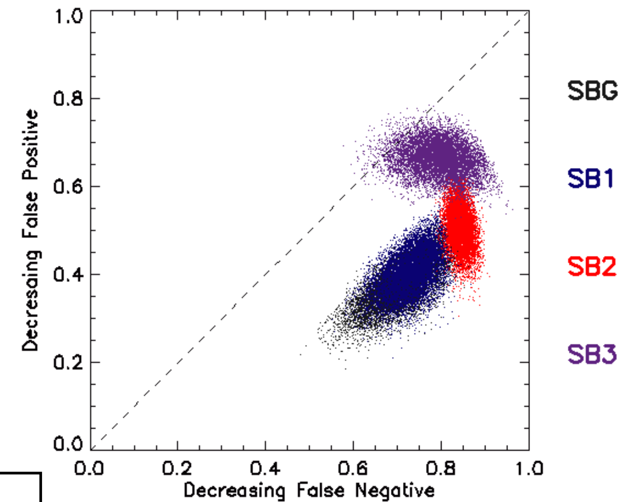
ANL Botanical Gardens mini-Sodar MOEs as a function of cutoff altitude for DM

Day

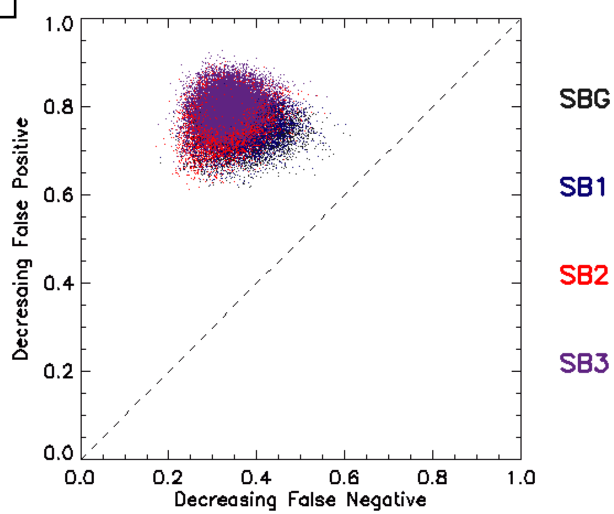
Night

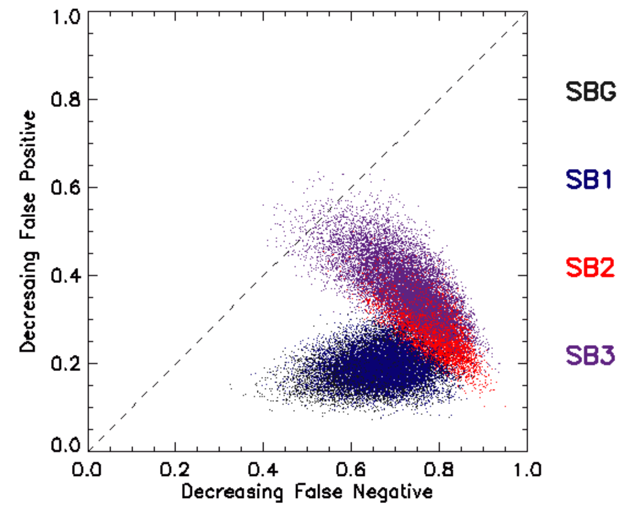
250 ppt threshold





average concentration

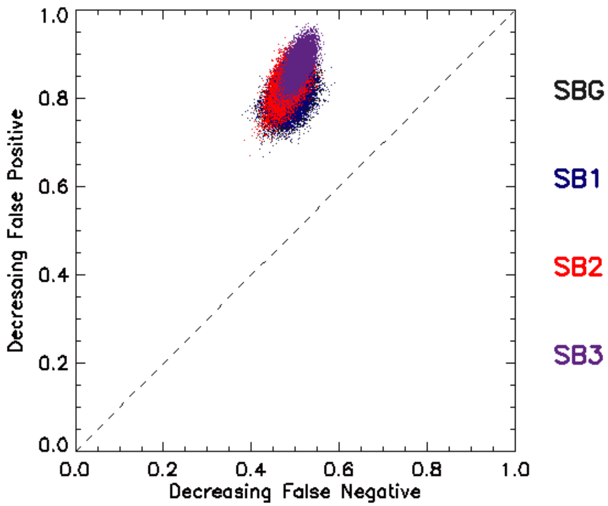




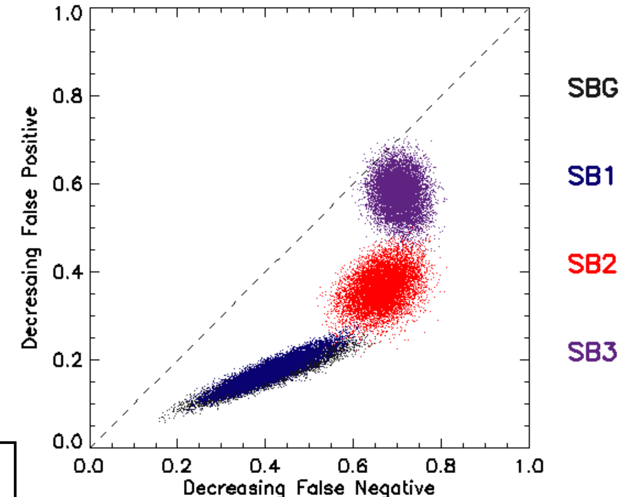
ANL Botanical Gardens mini-Sodar MOEs as a function of cutoff altitude for UC

250 ppt threshold

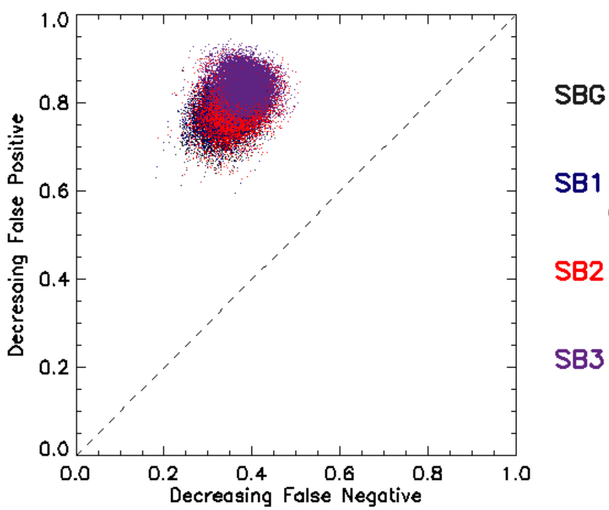
Day

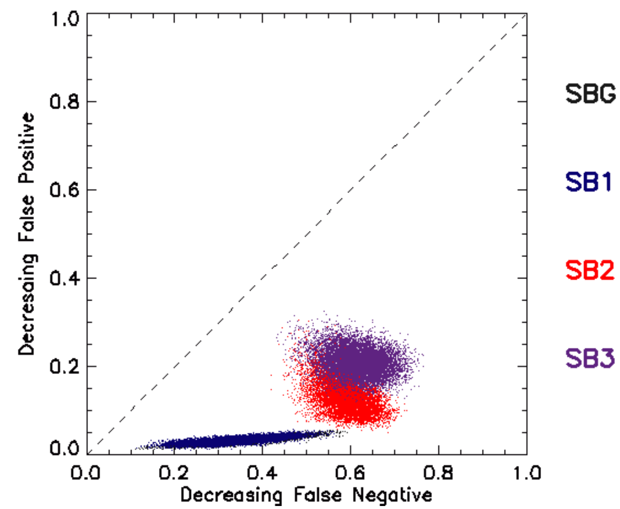


Night

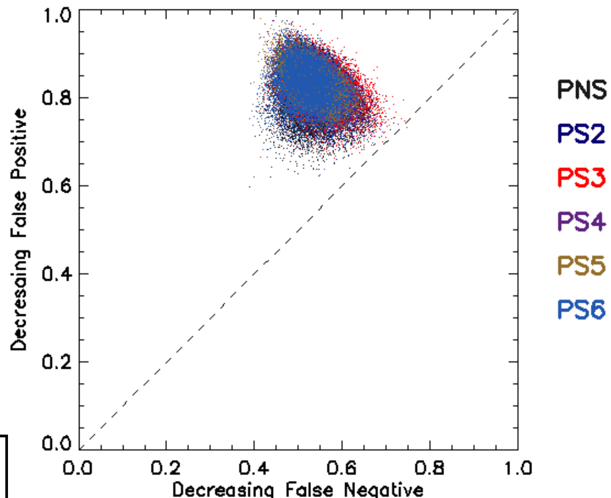


average concentration

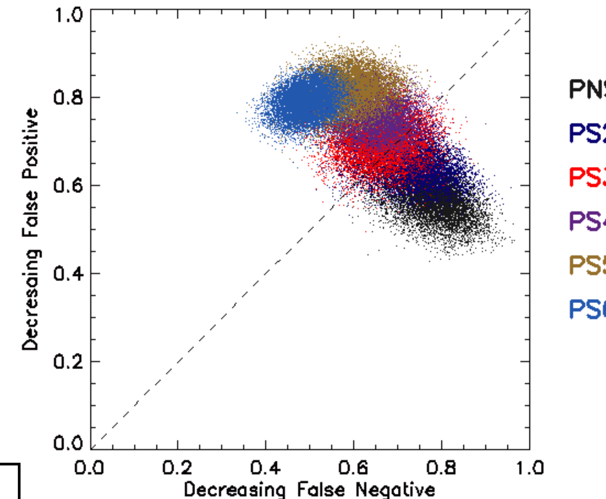




PNNL Sodar MOEs as a function of cutoff altitude for DM

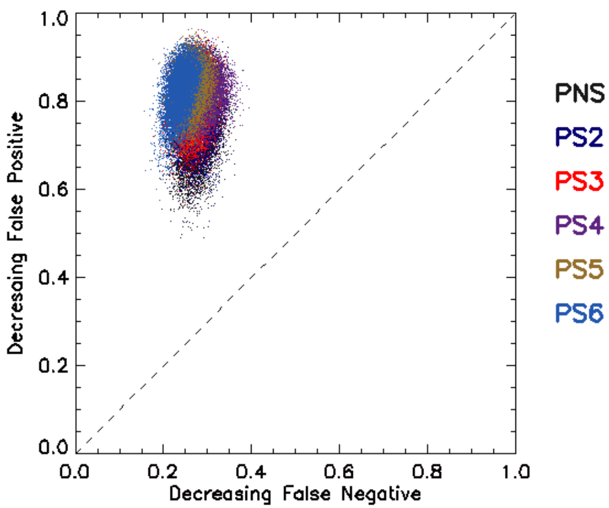


250 ppt threshold

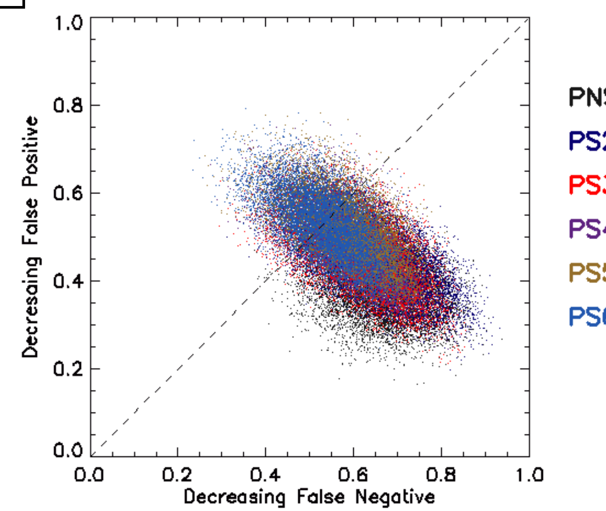


Day

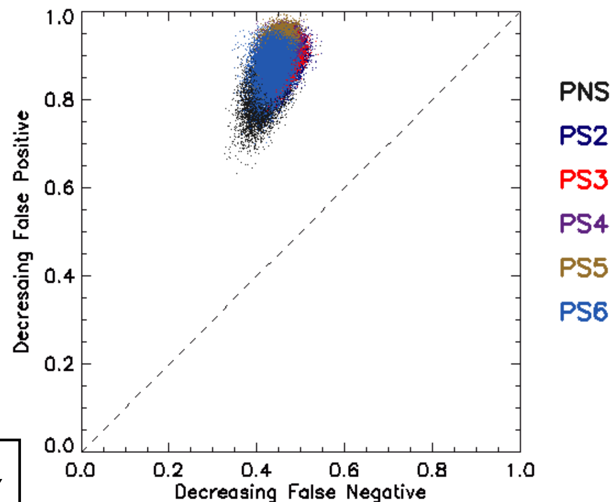
Night



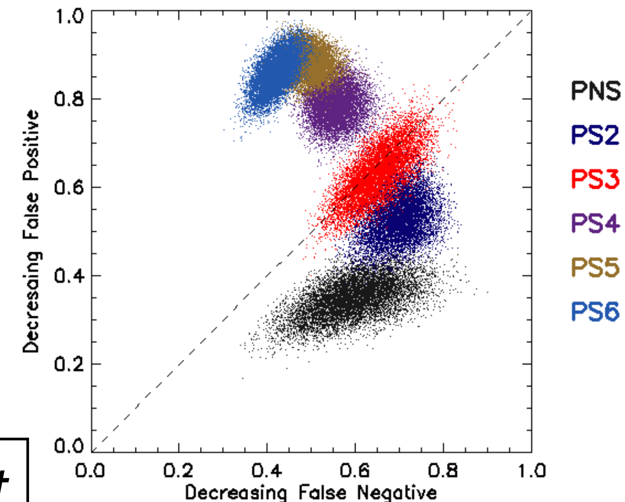
average concentration



PNNL Sodar MOEs
as a function of cutoff altitude for UC

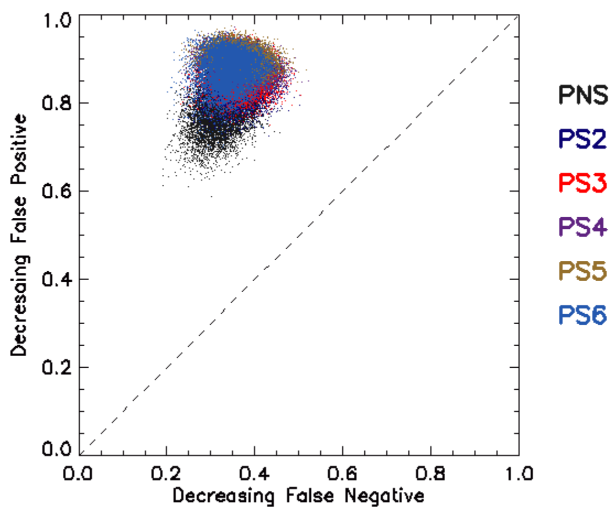


250 ppt threshold

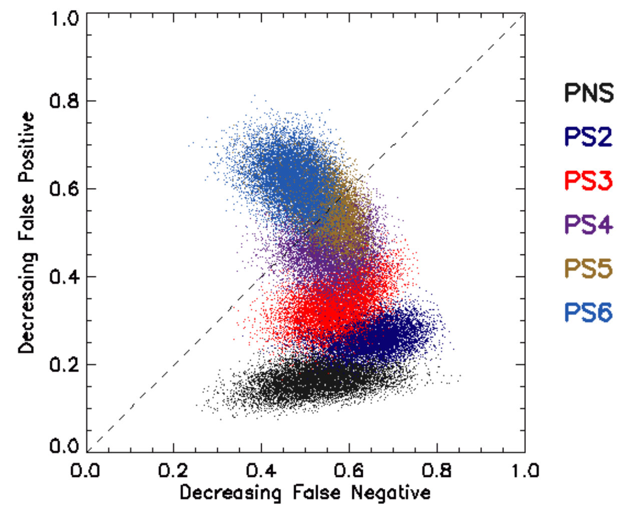


Day

Night

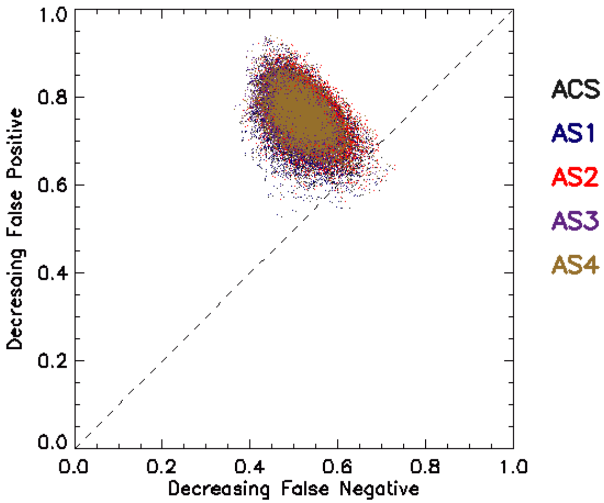


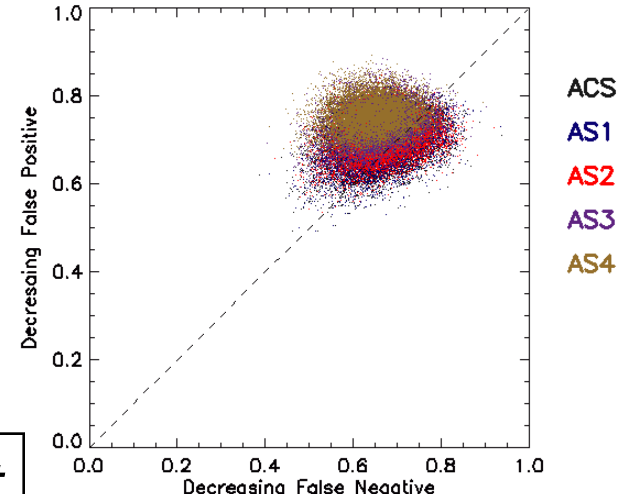
average concentration



ANL CC Sodar MOEs as a function of cutoff altitude for DM

250 ppt threshold

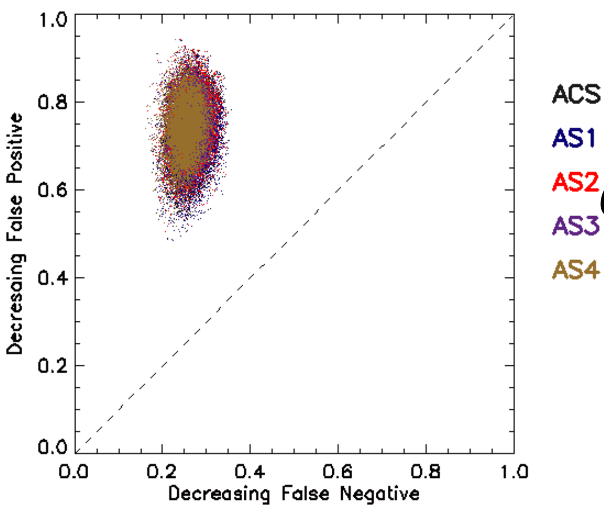


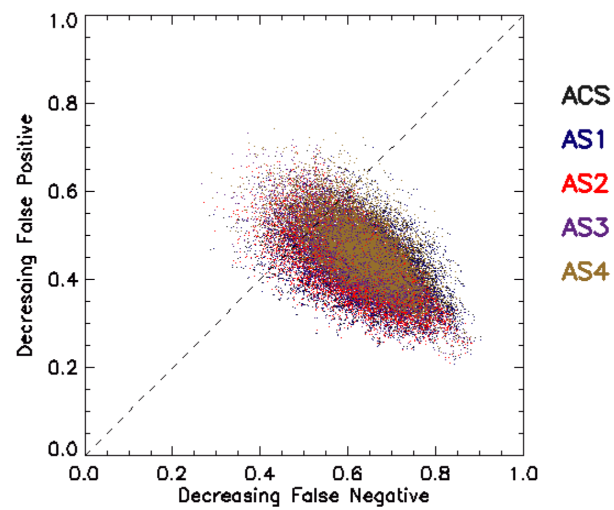


Day

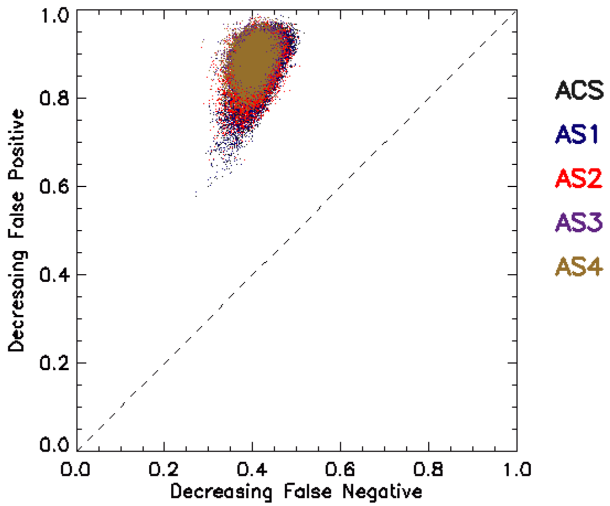
Night

average concentration

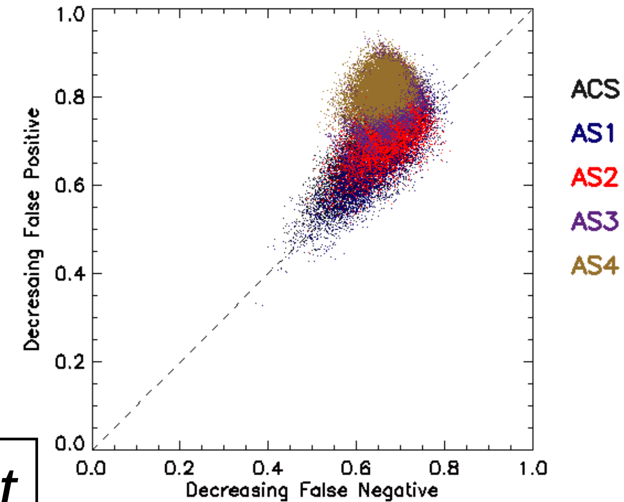




ANL CC Sodar MOEs as a function of cutoff altitude for UC

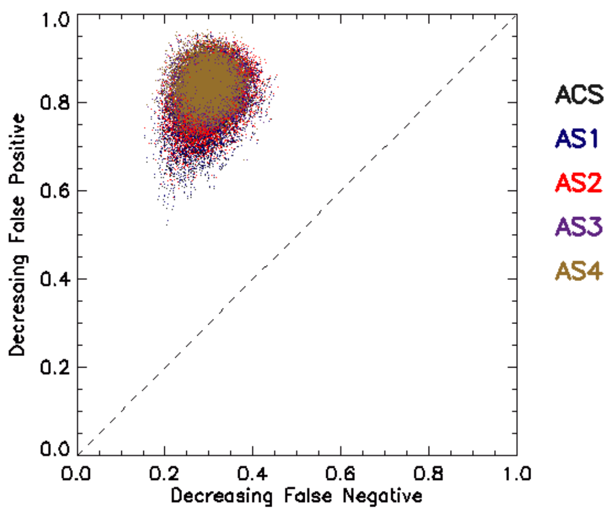


250 ppt threshold

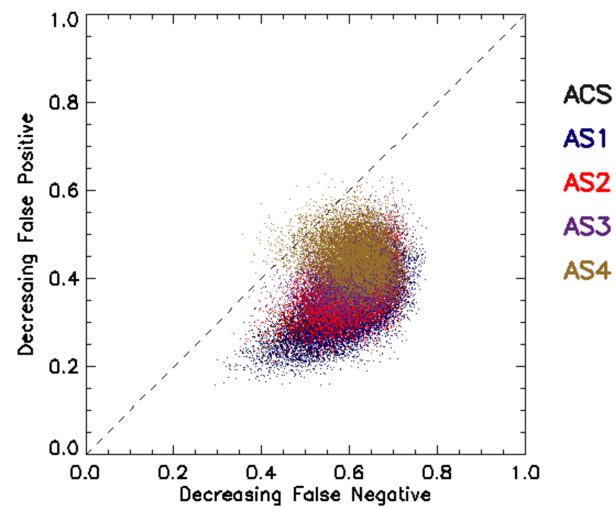


Day

Night



average concentration



Conclusions

- **At night, (mini) Sodar measurement below ~70-100 meters should not be used when running URBAN HPAC predictions for JU2003**
  - This is consistent for all (mini) sodars that have enough altitude data collected

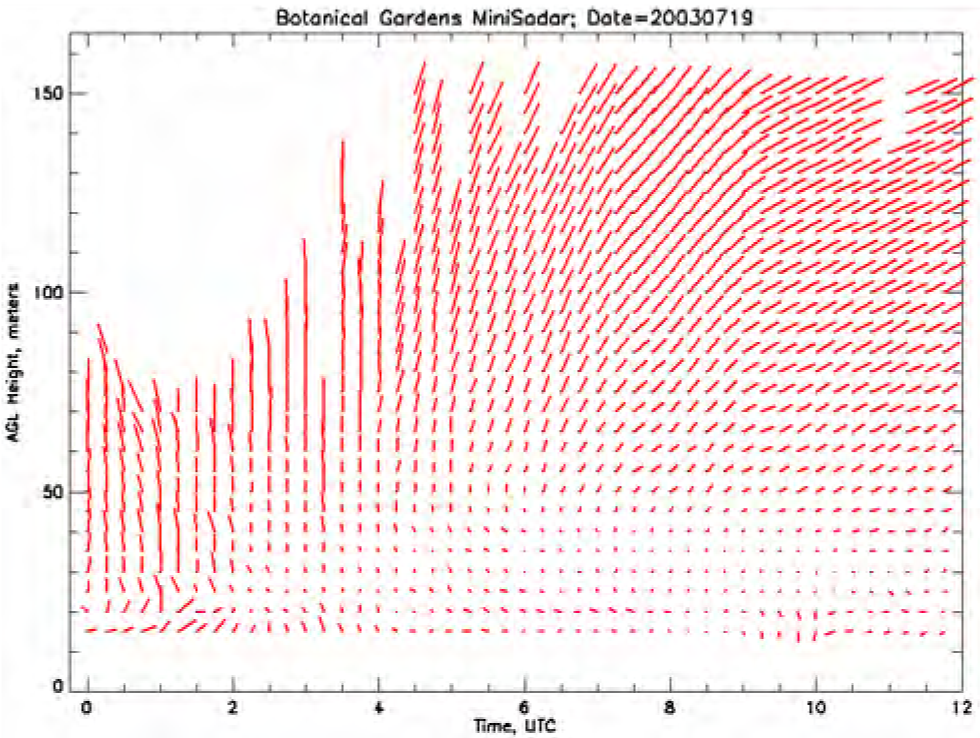
- **There is something going on in Oklahoma City at night that seems to create different flow at low altitude vs. higher altitude**
  - Seems to have a "separated" flow in the city from outside flow
  - This seems to be consistent for all (mini) sodars that have enough altitude data collected
  - Could be similar to changing stability category from Unstable/Neutral to Stable

Are (mini) Sodars prone to miscalculate winds at low altitude at night?

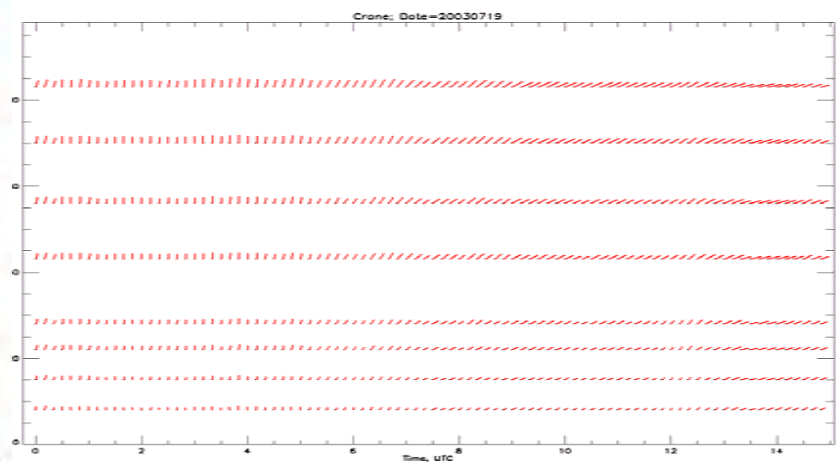
Are there exceptions?

- **Crane Sonics produce different behavior as low altitude winds are removed**

Botanical Gardens mini-Sodar

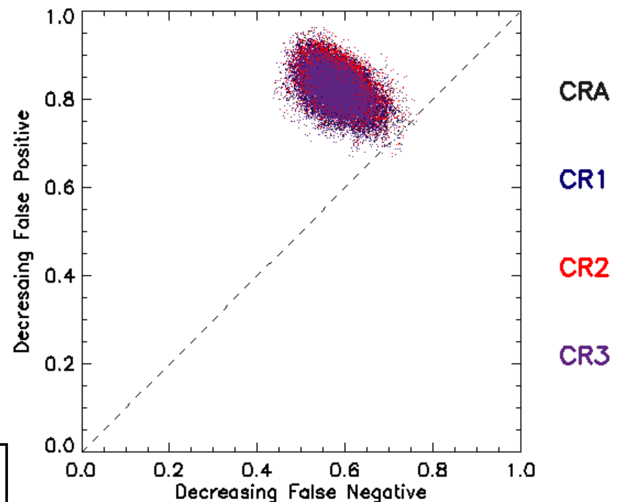


Crane Sonics

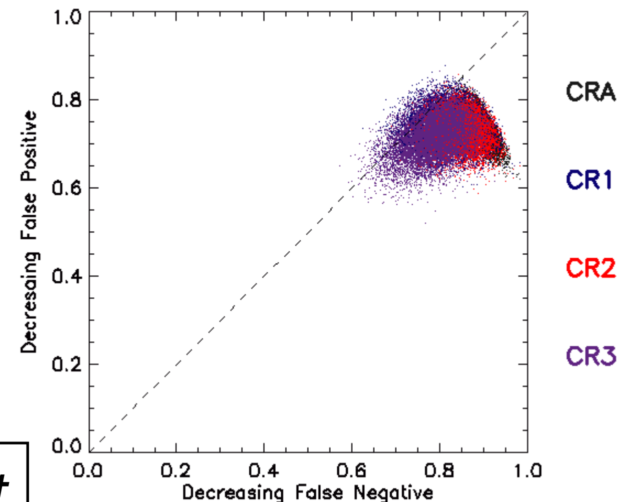


- **Crane Sonics wind data itself is different from mini (Sodars)**
  - **No high altitude data (above 85 meters)**
  - **Altitude data is sparce**

Crane MOEs
as a function of cutoff altitude for DM

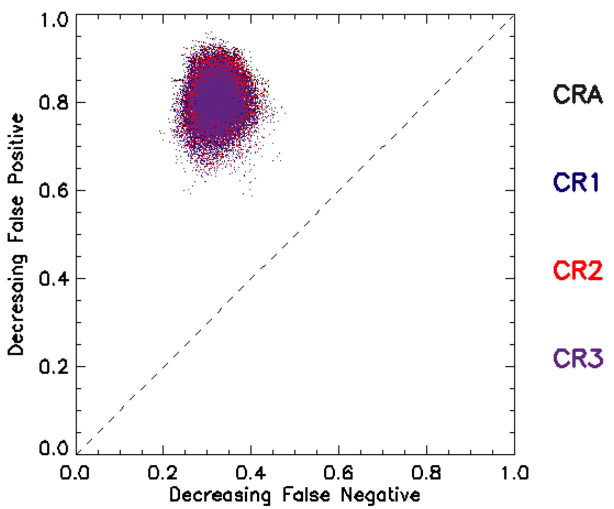


250 ppt threshold

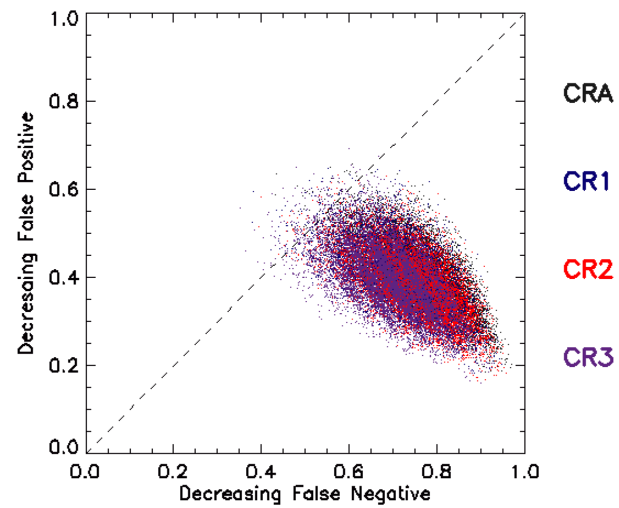


Day

Night



average concentration



Future Plans

- **Work in progress**
- **Will try to look at additional wind profile data**
  - Couple of wind profilers, but lowest altitude is ~80 meters
- **Would like to see if similar conclusions holds with other urban models**
  - MESO/RUSTIC
  - QUIC-URB/QUIC-PLUME
- **Will examine Lidar and other sources of real-time data**

MEDOC vs PROFILE ALL met input formats

Work in Progress …

CCAM Met

- **CCAM is an Australian wind field prediction model developed by the Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO)**
  - In 2005, Ralph Gailis (from Defense Science and Technology Organization (DSTO)) asked if we could use CCAM to drive HPAC JU2003 predictions to compare with observations and other wind models
- **Received CCAM MET in May 2006**
  - Files are MEDOC files
    - » Cannot be used with MSS
- **Run Urban HPAC predictions using CCAM MET input options**
- **Observed that predictions based on CCAM behave quite differently from predictions based on other met options**

For MET files in MEDOC format HPAC runs very fast

Which MET input Options Should be Used for Comparison with CCAM

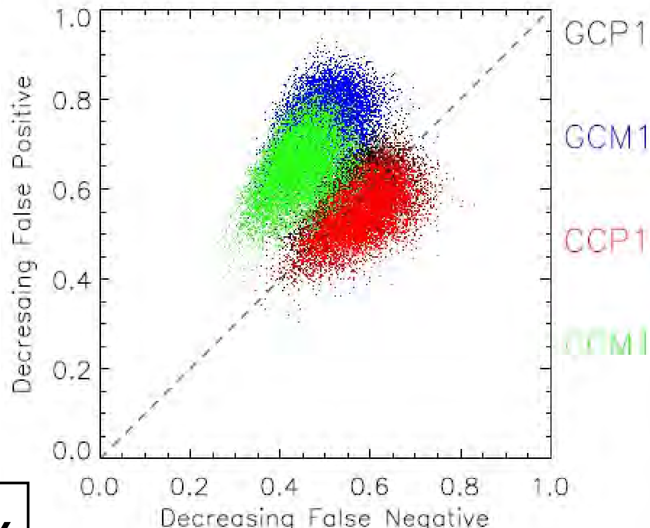
- **Originally, we wanted to use GCAT (PROFILE ALL) and BAS (nearby airport observations) MET input options for comparison**
  - Unfortunately, both of these use SWIFT first to obtain mass-consistent winds that could produce significant effects on resulting predictions
    - » Incidentally, we run “low-resolution” WM and DW configuration for Post Office rooftop met with MC-SCIPUFF instead of SWIFT, and we were quite “surprised” by the results
- **Early GCAT files were in MEDOC format, so we decided to compare CCAM predictions to GCAT- MEDOC predictions**
- **Interestingly enough, GCAT MEDOC and PROFILE ALL MET input options produce quite differently behaving predictions**
  - GCAT MEDOC (GCM1) predictions seem to push simulant clouds much faster than GCAT PROFILE ALL (GCP1) predictions
    - » Observations support slower speeds

MEDOC to PROFILE ALL Converter

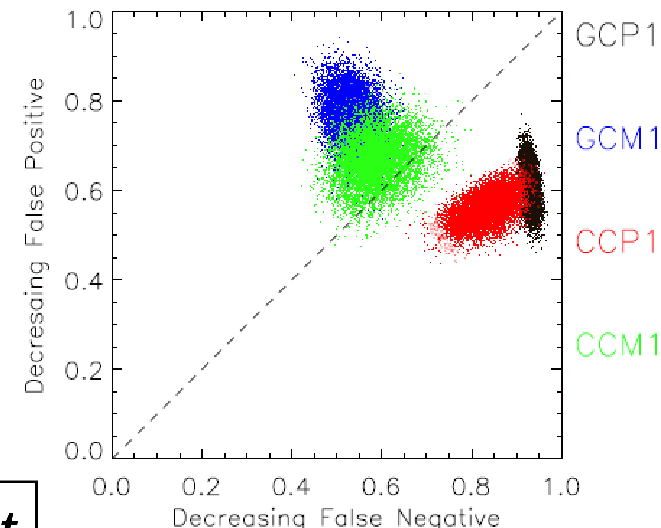
- **Contacted NGIC to find out what is going on with GCAT**
- **NGIC contacted GCAT developer (NCAR)**
- **As part of diagnostic, NCAR wrote a MEDOC to PROFILE ALL met converter and graciously offered source code to us**
- **We created 4 sets of predictions**
  - **GCM1** based on early GCAT MEDOC met input
  - **GCP1** based on converted GCAT MEDOC met input
  - **CCM1** based on CCAM 1 km MEDOC met input
  - **CCP1** based on converted CCAM 1 km MEDOC met input
- **Observed that MEDOC predictions are comparable to each other, but different from PROFILE ALL predictions**

Note: For GCAT MEDOC files converter is not 1-to-1 because some temperature data was not recorded in the original MEDOC file

MEDOC vs PROFILE ALL
for UDM Predictions

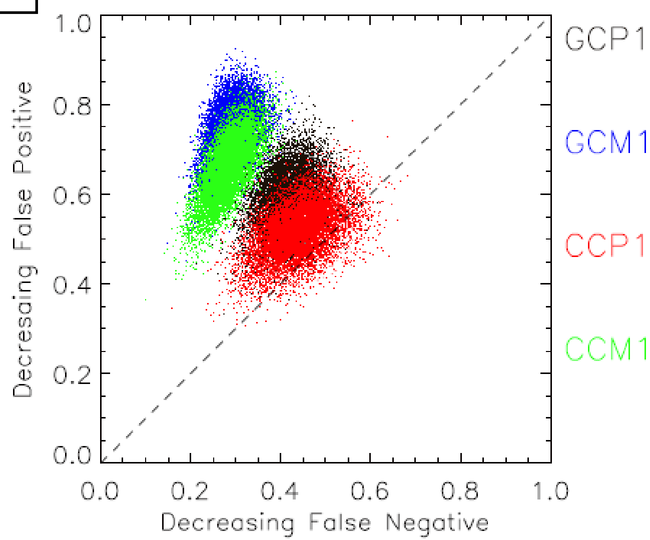


250 ppt threshold

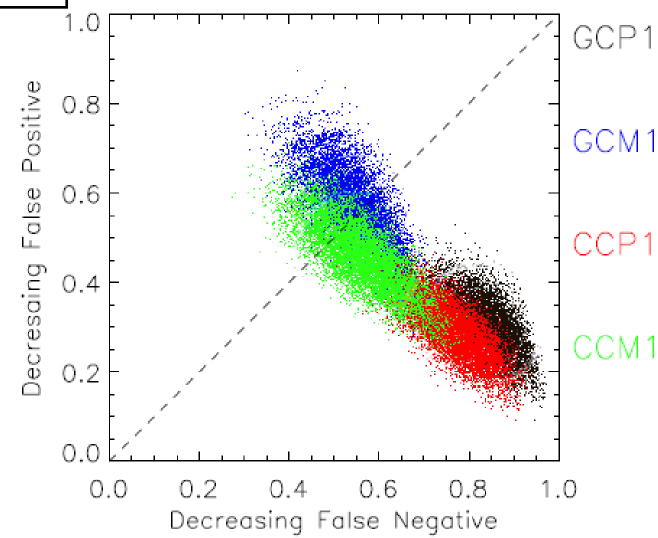


Day

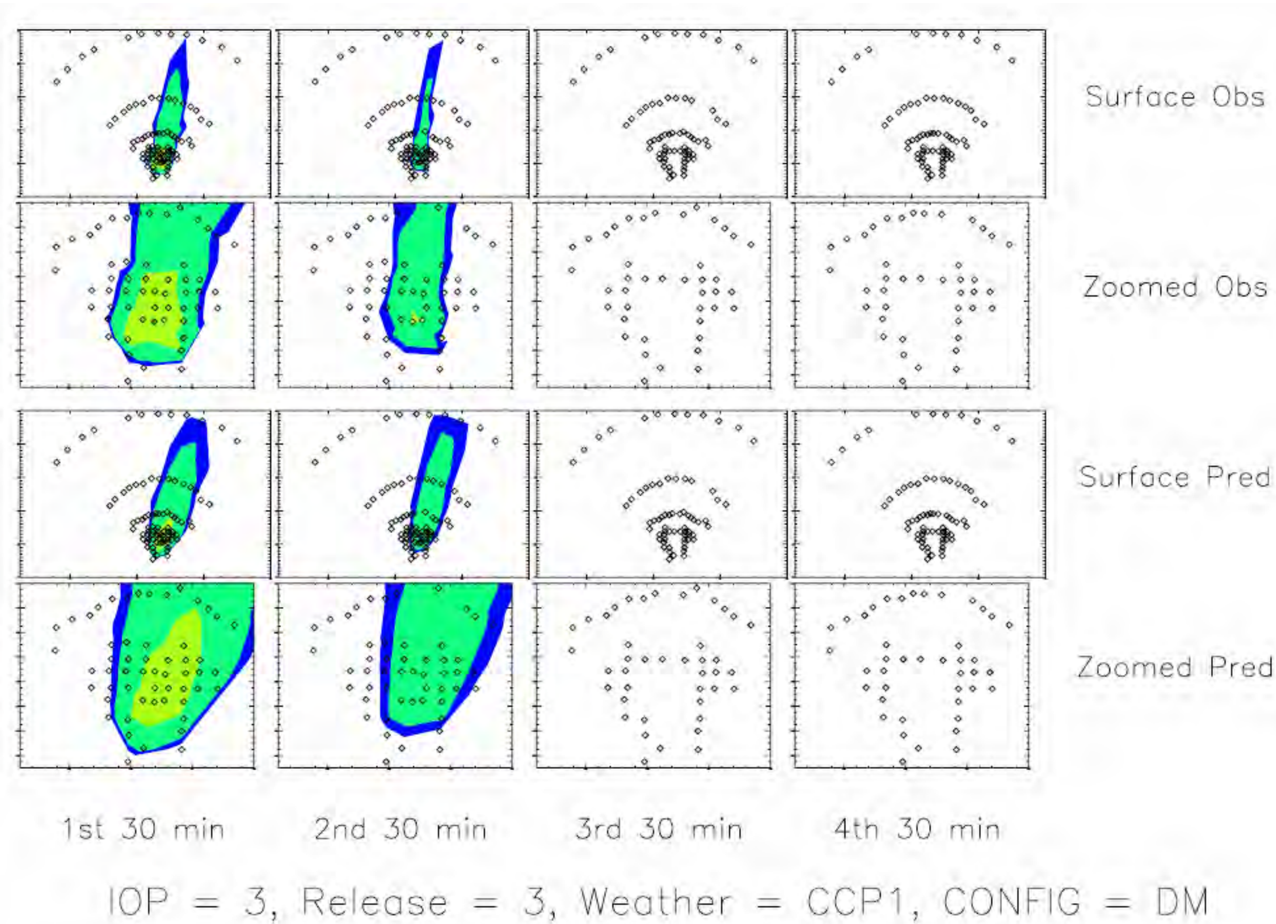
Night



average concentration

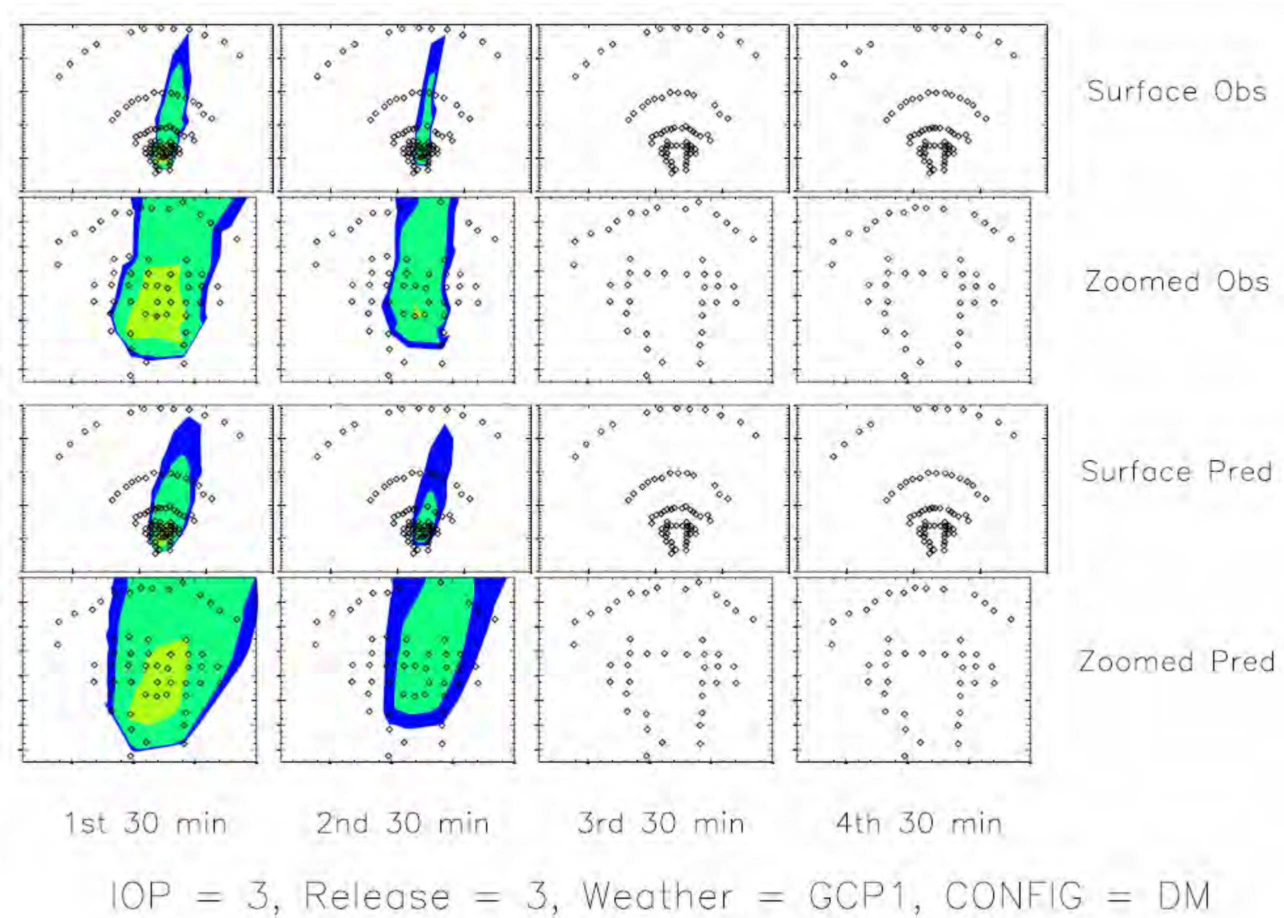


CCAM PROFILE ALL Predictions vs Observations



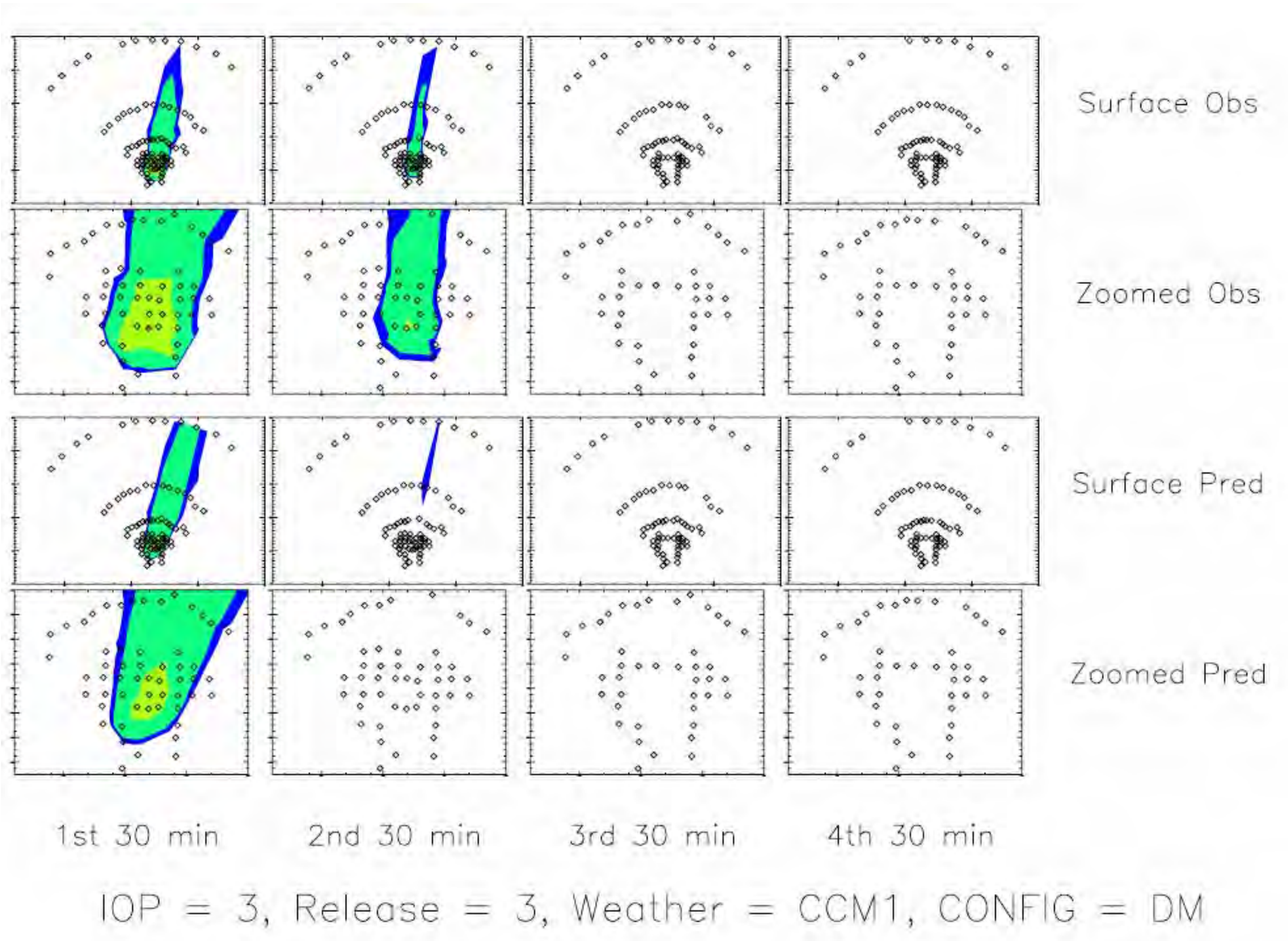
Predictions seems to be in-sync (30 minute interval) with observations

GCAT PROFILE ALL Predictions vs Observations



Predictions seems to be in-sync (30 minute interval) with observations

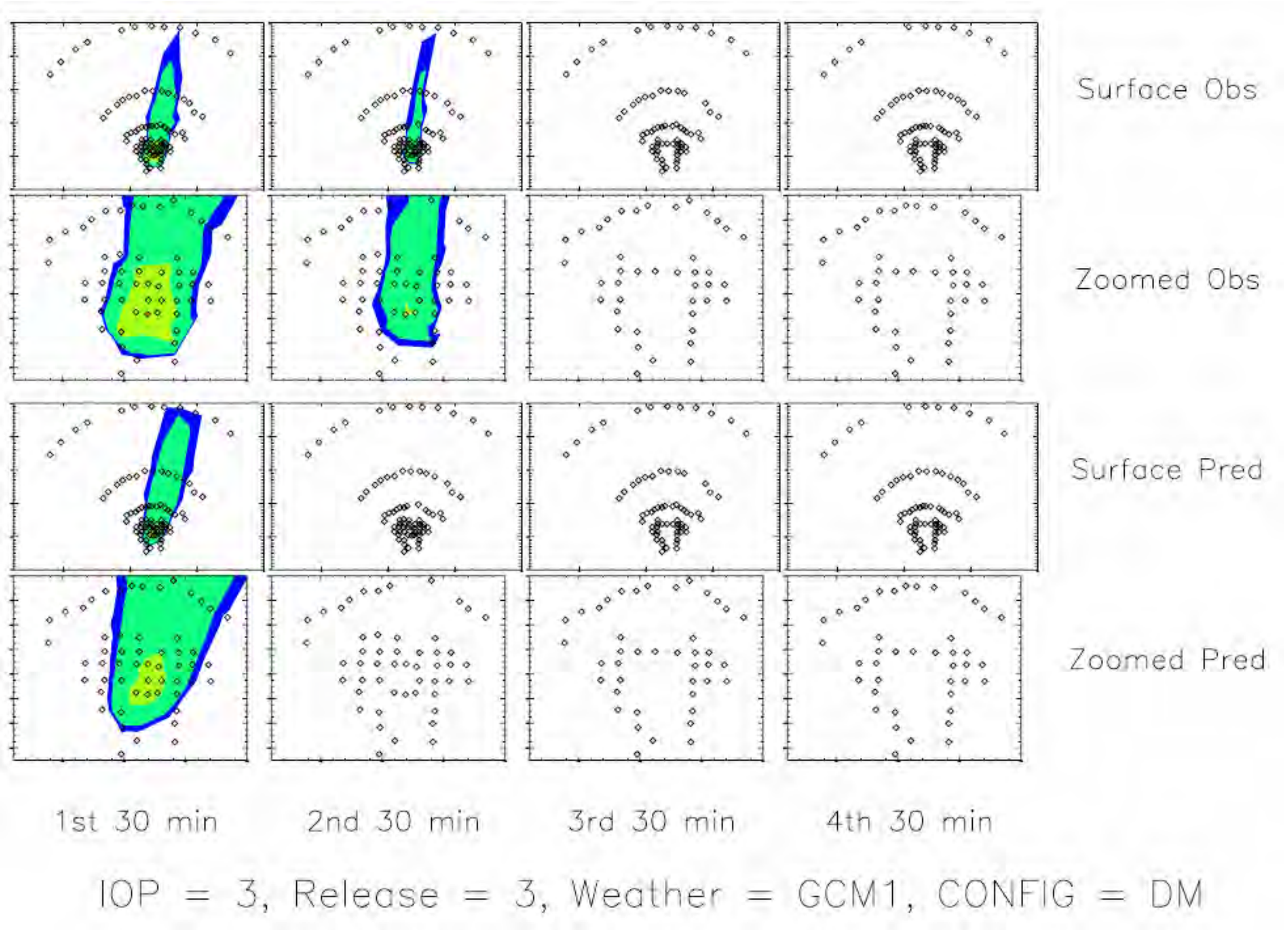
CCAM MEDOC Predictions vs Observations



This is not as noticeable with UC or at night, but since HPAC generally over-predicts significantly at night, we suspect that double-wrong makes it look OK

CCAM MEDOC predictions seem to push clouds too fast

GCAT MEDOC Predictions vs Observations



This is not as noticeable with UC or at night, but since HPAC generally over-predicts significantly at night, we suspect that double-wrong makes it look OK

GCAT MEDOC predictions seem to push clouds too fast

Conclusions and Future Work

- **CCAM MEDOC and GCAT MEDOC winds seems to push clouds too fast**
  - Compared to SWIFT and MC-SCIPUFF processed MET
  - Some indications that this is also true for comparison with observations
    - » Daytime seems to show for 30-minute averaged concentrations
    - » Nighttime is harder to see, but it might be due to compensating errors
      - Over-prediction followed by faster “removal”

- **GCAT and CCAM MEDOC and GCAT and CCAM PROFILE ALL MET input options produce significantly different predictions**
  - We really need to understand why this is happening
    - » Does MEDOC MET always have this “problem” that might lead to seemingly better predictions at night because of compensating errors?
    - » MEDOC MET runs much faster on HPAC, thus there is a great interest in using this MET for real-time hazard prediction
    - » What does SWIFT (or MC-SCIPUFF) do to slow down T&D?
  - Similarly, need to understand differences between SWIFT and MC-SCIPUFF
    - » MC-SCIPUFF is much faster running than SWIFT making it attractive to real-time hazard prediction
    - » Incidentally, we run “low-resolution” WM and DW configuration for Post Office rooftop met with MC-SCIPUFF instead of SWIFT, and we were quite “surprised” by the results which we speculate were resulting from compensating errors

Multi-Objective Optimization Methods for Optimal Funding Allocations to Mitigate Chemical and Biological Attacks

Roshan Rammohan, Ryan Schnalzer
Mahmoud Reda Taha, Tim Ross and Frank Gilfeather
University of New Mexico

Ram Prasad

New Mexico State University

Outline

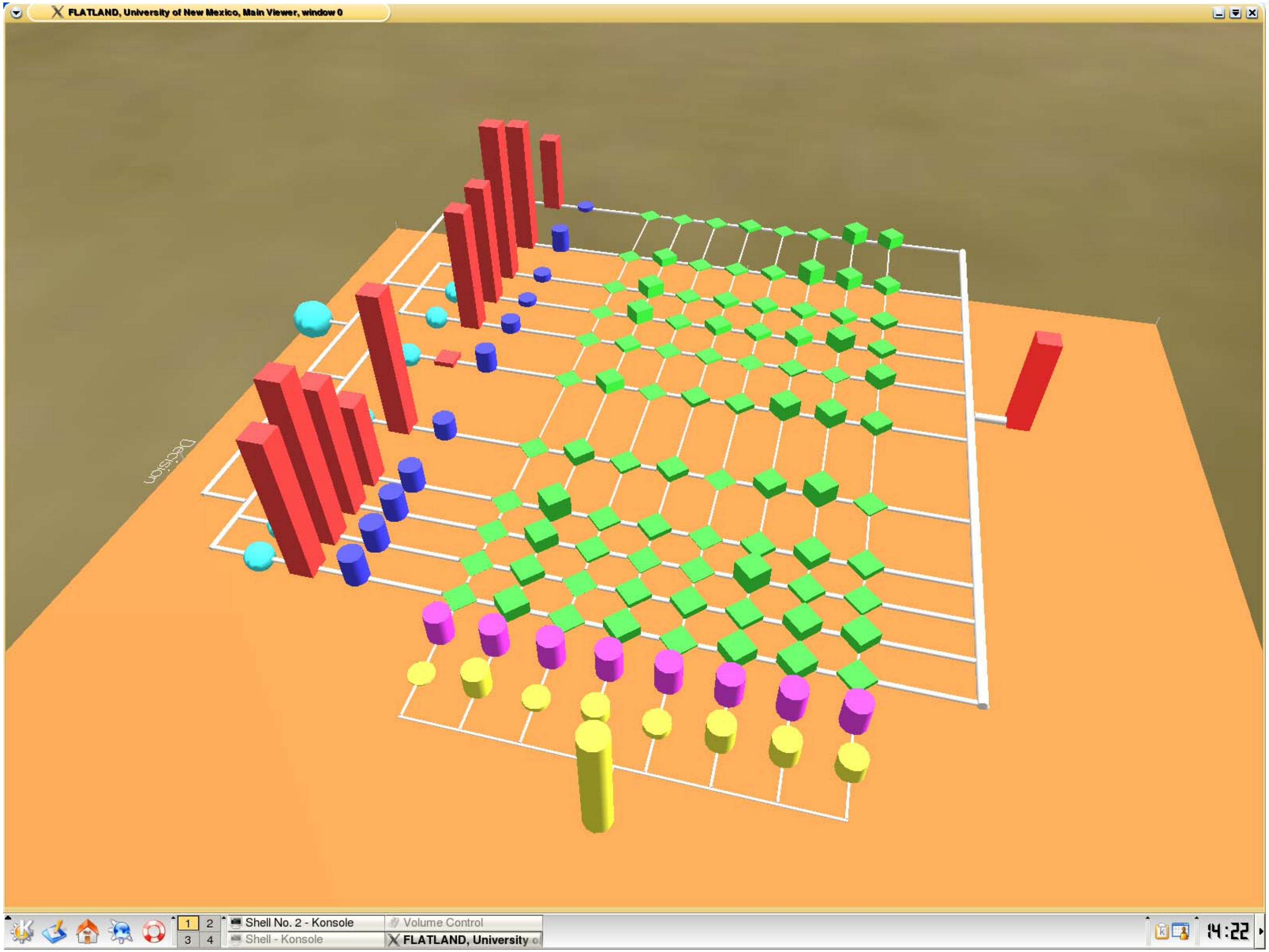
- ❑ Introduction
- ❑ MIDST: Exploration Mode
- ❑ MIDST: Optimization mode
- ❑ Alterative Optimization Methods
- ❑ Case study
- ❑ Conclusions

Introduction

❑ MIDST: Problem Statement

What is the ***optimal*** budget ***$B*** and its distribution to ***N investment units*** in order to reduce the consequences of ***S number of CB events***?

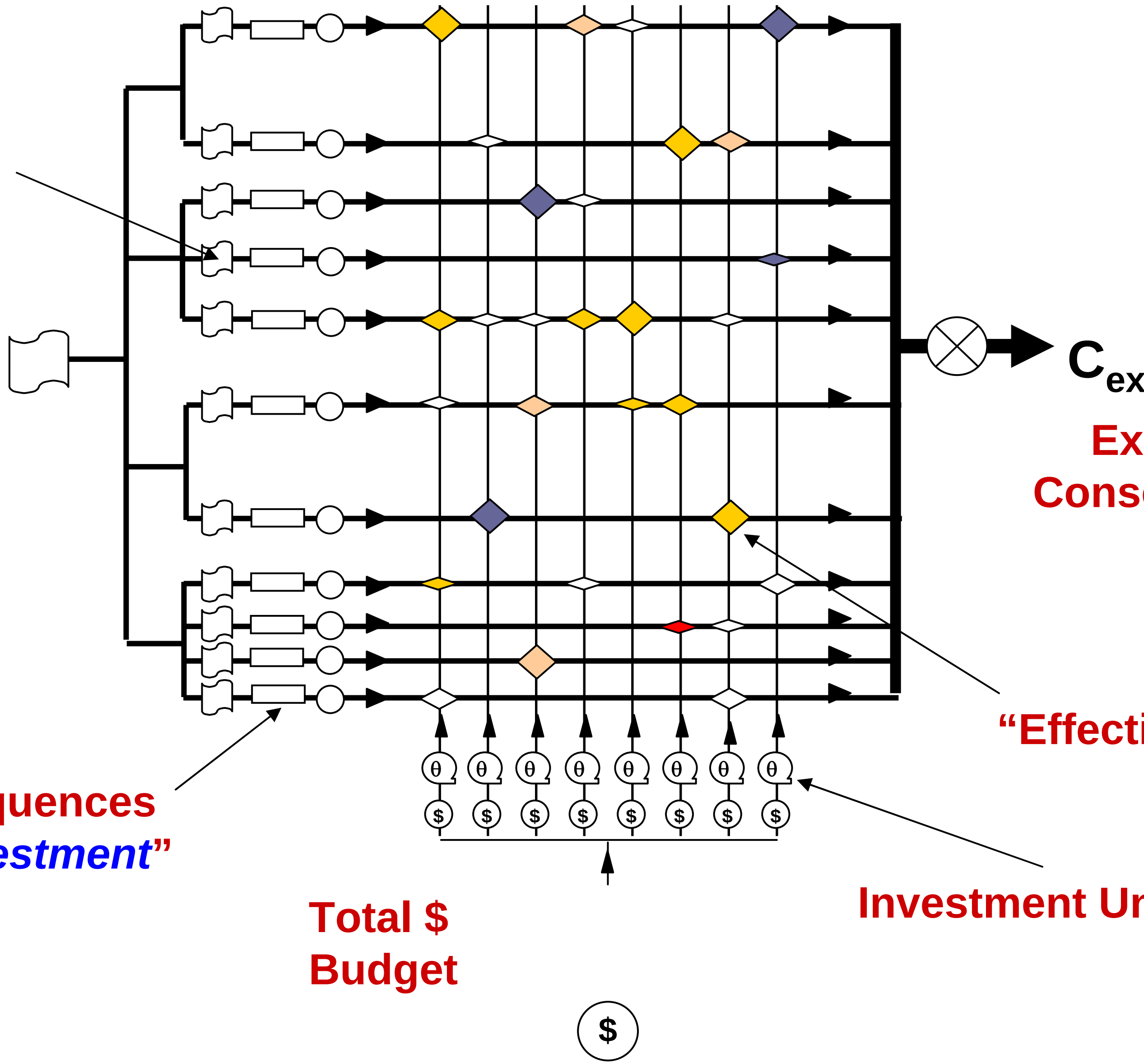
Introduction



Introduction

All possible individual CB events

CB event Class



Expected Consequences

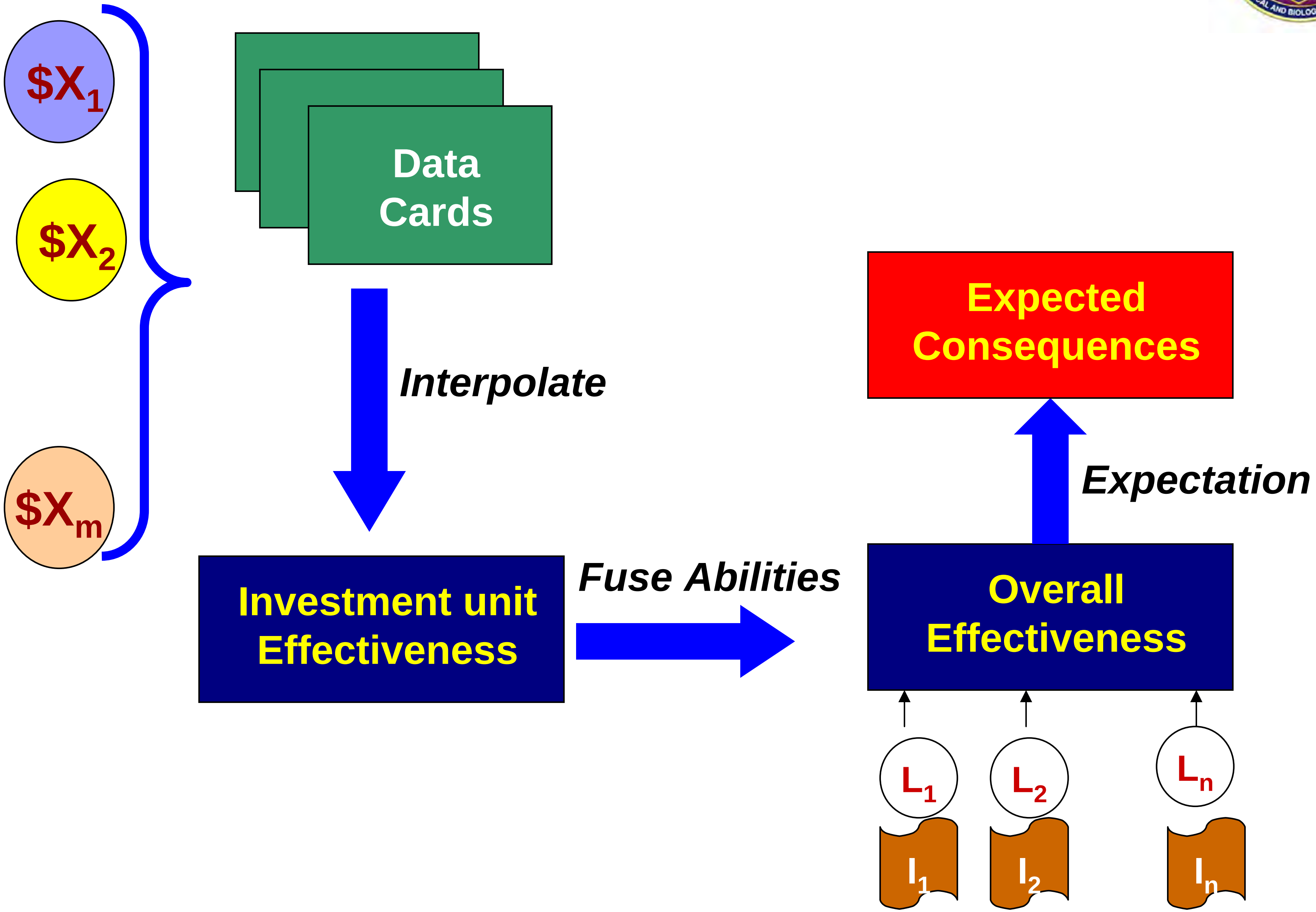
"Effectiveness"

Consequences *"No Investment"*

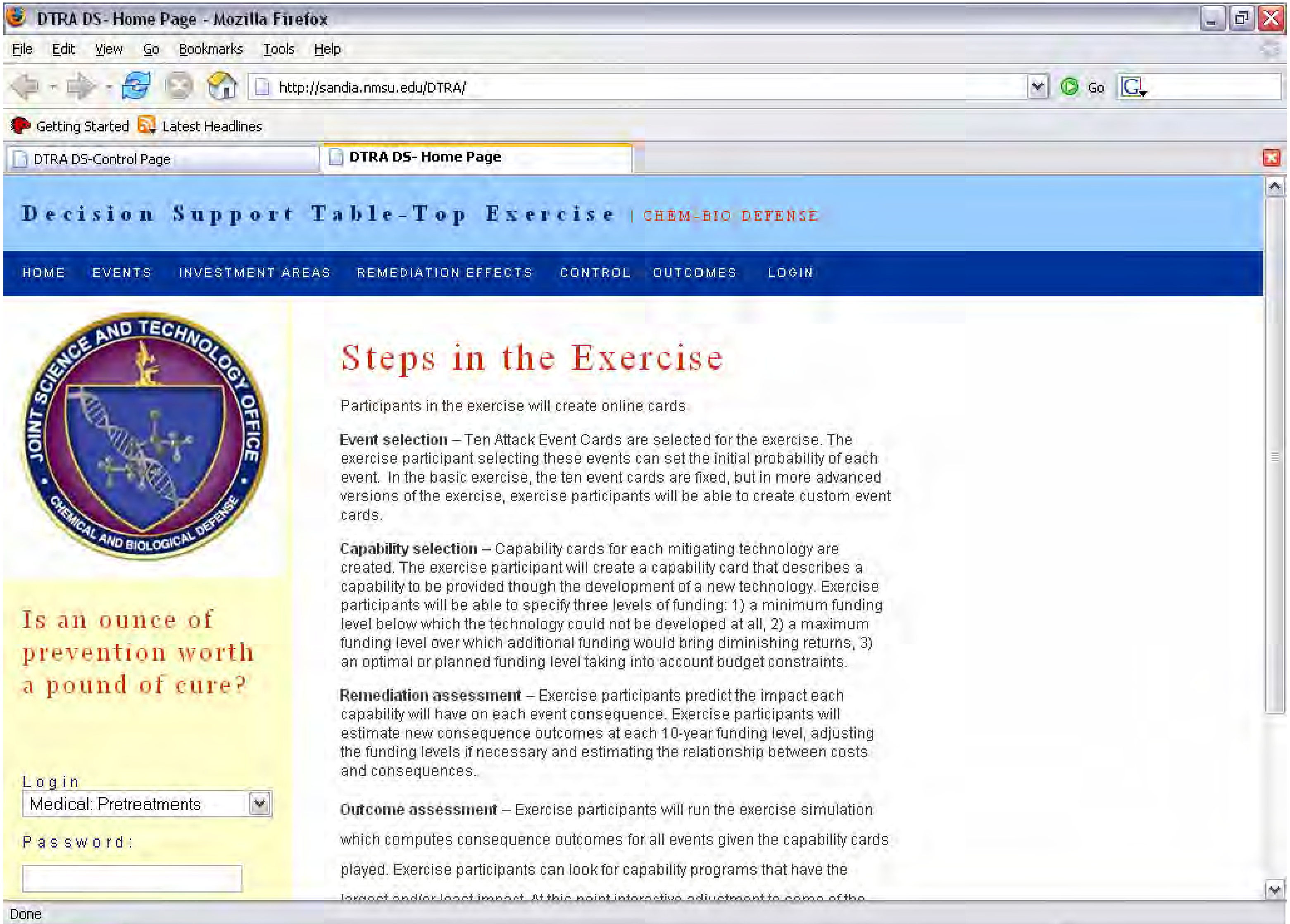
Investment Units "N"

Total $ Budget

MIDST: Exploration Mode



Soliciting Information: Data Cards



Soliciting Information: Data Cards

http://sandia.nmsu.edu/DTRA/remediation.php

DTRA DS-Control Page | DTRA DS- Remediation Effects

Predict outcome given Vaccines for bacterial agents (anthrax) remediation is in place:

	Effectiveness Prediction		
Funding Level	Casualties	Days to recover	Mission Disruption
Event Baseline	5%	30	50%
Threshold ($20M)	Highly effective	Highly effective	Highly effective
Productive ($37M)	Highly effective	Highly effective	Highly effective
Optimal ($50M)	Completly effective	Completly effective	Completly effective

Predict outcome given Vaccines for bacterial agents (plague) remediation is in place:

	Effectiveness Prediction		
Funding Level	Casualties	Days to recover	Mission Disruption
Event Baseline	5%	30	50%
Threshold ($30M)	Not effective	Not effective	Not effective
Productive ($50M)	Not effective	Not effective	Not effective
Optimal ($60M)	Not effective	Not effective	Not effective

Predict outcome given Nerve Agent bioscavengers remediation is in place:

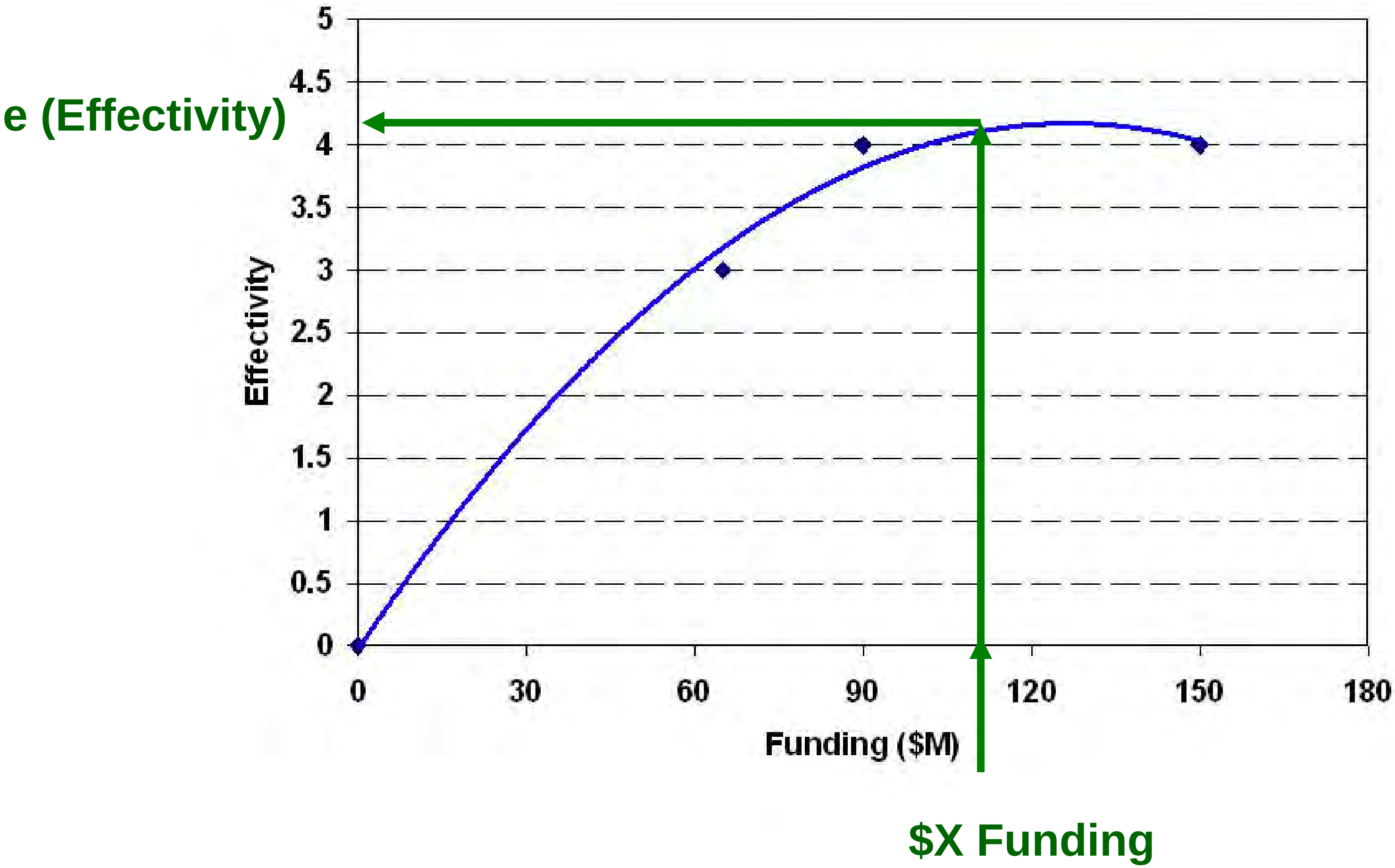
	Effectiveness Prediction		
Funding Level	Casualties	Days to recover	Mission Disruption
Event Baseline	5%	30	50%
Threshold ($166M)	Not effective	Not effective	Not effective
Productive ($166M)	Not effective	Not effective	Not effective
Optimal ($250M)	Not effective	Not effective	Not effective

Predict outcome given Multiagent Vaccines remediation is in place:

	Effectiveness Prediction		
Funding Level	Casualties	Days to recover	Mission Disruption
Event Baseline	5%	30	50%

Establishing effectivity function

- Polynomial or ***spline*** interpolation
- ***Multivariate*** interpolation (See ***Prasad et al.*** tommorow!)



Establishing effectivity function

- Using this method we establish the matrix of effectivity

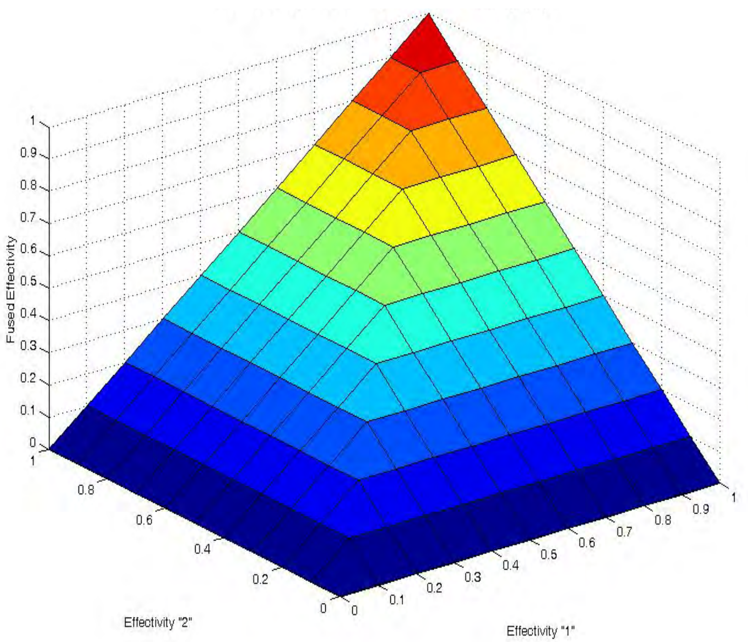
$$\bar{e} = \begin{Bmatrix} e_{1,1} & e_{1,2} & \ldots e_{1,i} & \cdots & e_{1,N} \\ e_{2,1} & e_{2,2} & \ldots e_{2,i} & \cdots & e_{2,N} \\ e_{m,1} & e_{m,2} & \ldots e_{m,i} & \cdots & e_{m,N} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ e_{S,1} & e_{S,2} & e_{S,i} & \cdots & e_{S,N} \end{Bmatrix}$$

For <u>N: investment units</u> and <u>S: CB events</u>

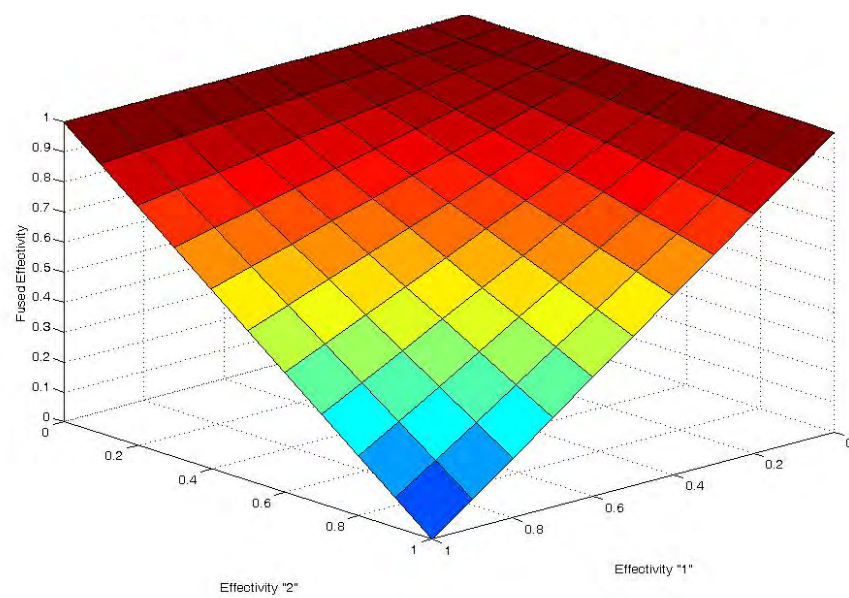
Fusing Effectivities

❑ Considering the ***interaction between IUs*** on the final consequences we have to fuse these effectivities

❑ Many fusion operators exist. ***Example 2D fusion:***



Very conservative



Very optimistic

Expected Consequences

- The fusion operation results in

$$\hat{e}^{fN} = \left\{ e_1^{fN}, e_2^{fN}, e_3^{fN} \ldots e_m^{fN} \ldots e_S^{fN} \right\}$$

For S: CB events

- The expected consequence for each CB event can be computed as

$$\overline{C_m^k} = \left(1 - \hat{e}_m^k \right) \overline{C_m^0}$$

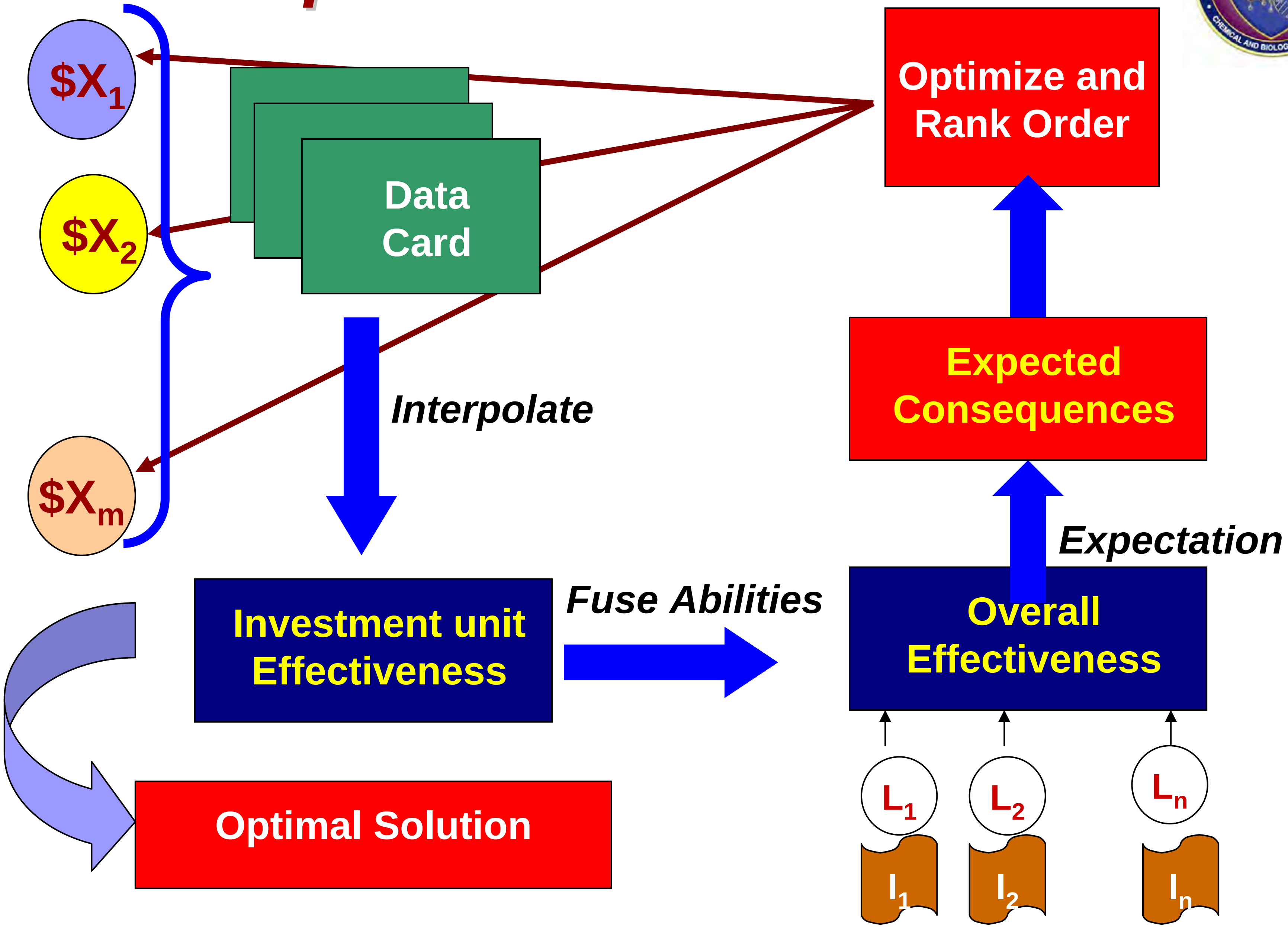
For each CB event

- Considering the likelihoods of the CB events we can compute the overall expected consequences as

$$\overline{C^k} = \sum_{m=1}^{S} L_m \overline{C_m^k}$$

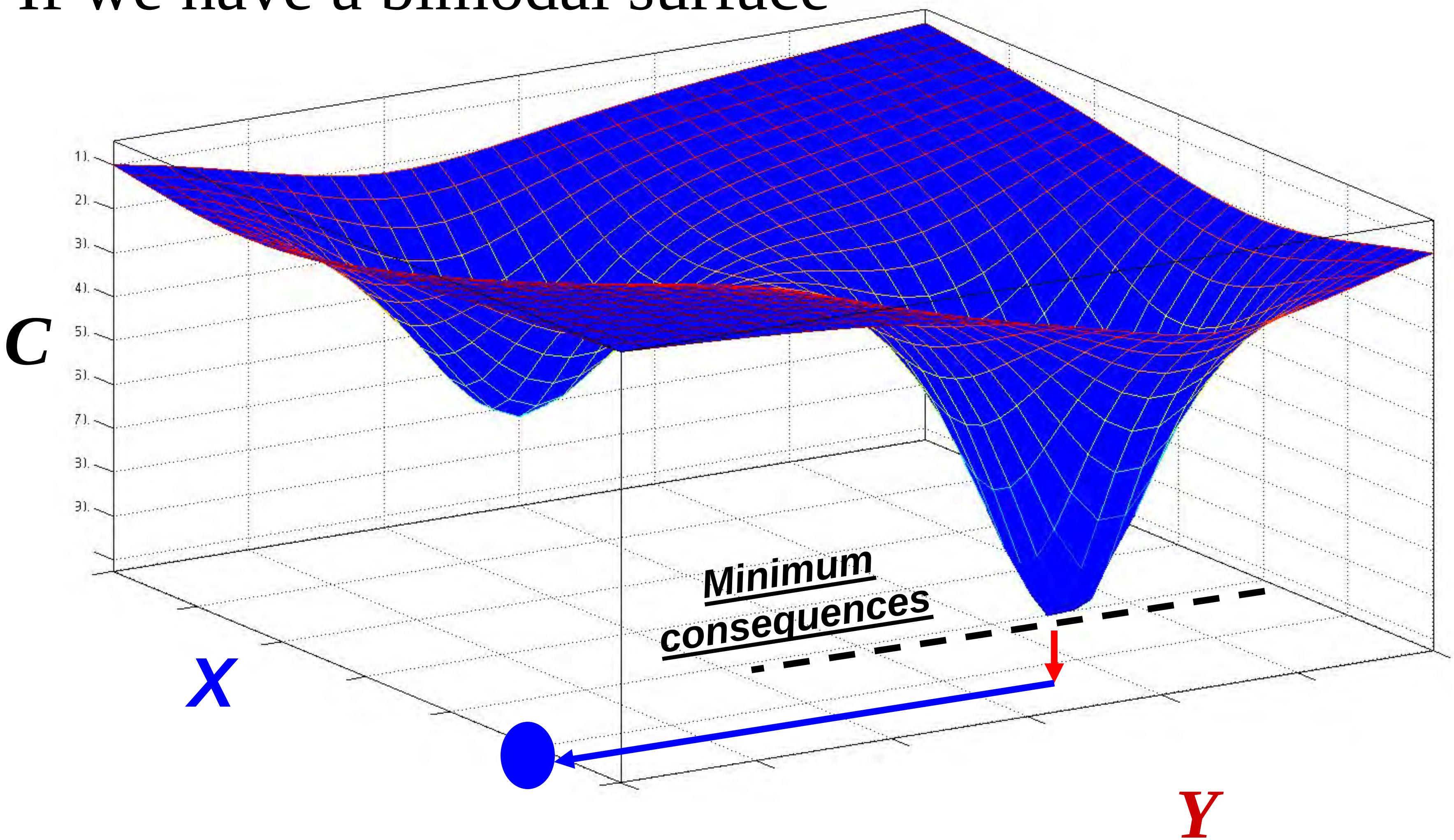
Vector of consequences at $k investment

MIDST: Optimization Mode



What does optimization mean?

If we have a bimodal surface



We need to ***identify "x"*** that results in ***minimum "C"***

Our optimization challenges are

- The surface of our ***function is not bimodal***

-There ***might be many local minima***

-There is ***more than one objective*** and ***they are not necessary achievable all together***

- ***Computing time, space*** and accuracy resolution

- Practical interests

Methods

- To address the risk associated with the previously listed concerns/challenges, a group of optimization methods was examined

  - ***Derivative based optimization***
    - Gradient descent method
    - Levenberg Marquadrt
    - Many other

  - ***Non-derivative based optimization***
    - Genetic algorithms
    - Simulated annealing
    - Many other

Derivative-free optimization

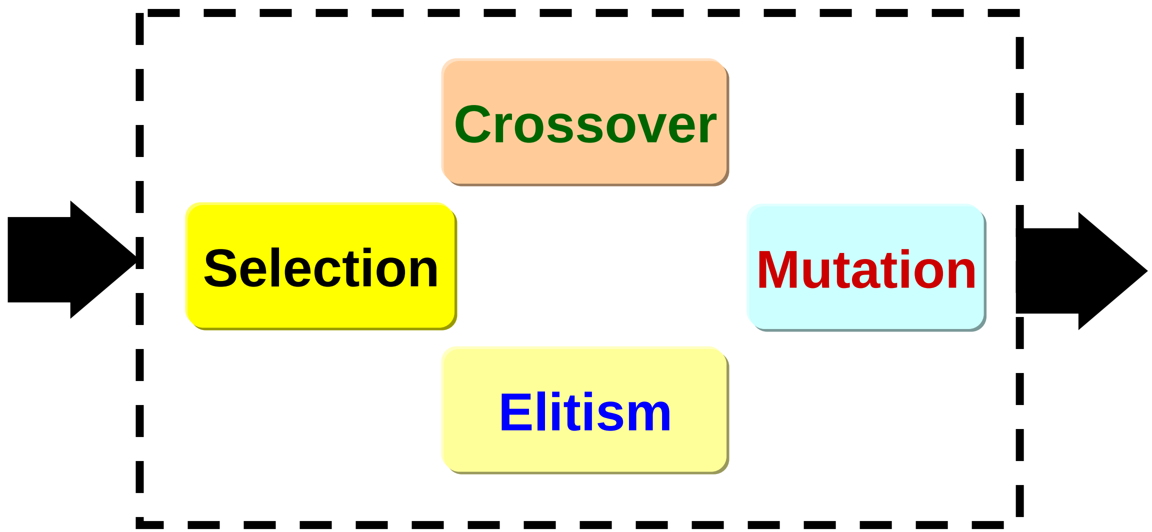
Genetic Algorithms (GA) mimics laws of ***Natural Evolution*** which emphasizes "***survival of the fittest***".

In GA a "***population***" that contains different possible solutions to the problem is created.

Genetic Algorithms

10010110
01100010
10100100
10011001
01111101
. . .
. . .
. . .
. . .

Initial generation



10010110
01100010
10100100
10011101
01111001
. . .
. . .
. . .
. . .

Next generation

The process is repeated until ***evolution happens***

"***a solution is found!***"

Multi-Objective Optimization

- It is practical to assume that the decision maker might have priorities on the different objectives ***casualties/mission disruption and time to recover***.

-In this case, usually ***there exist more than one optimal solution*** to the problem (Named ***Pareto solution***)

- Based on the preferences, these ***solutions can be rank ordered***.

Multi-Objective Optimization

- Three major issues differentiate between single and multi-objective optimizations

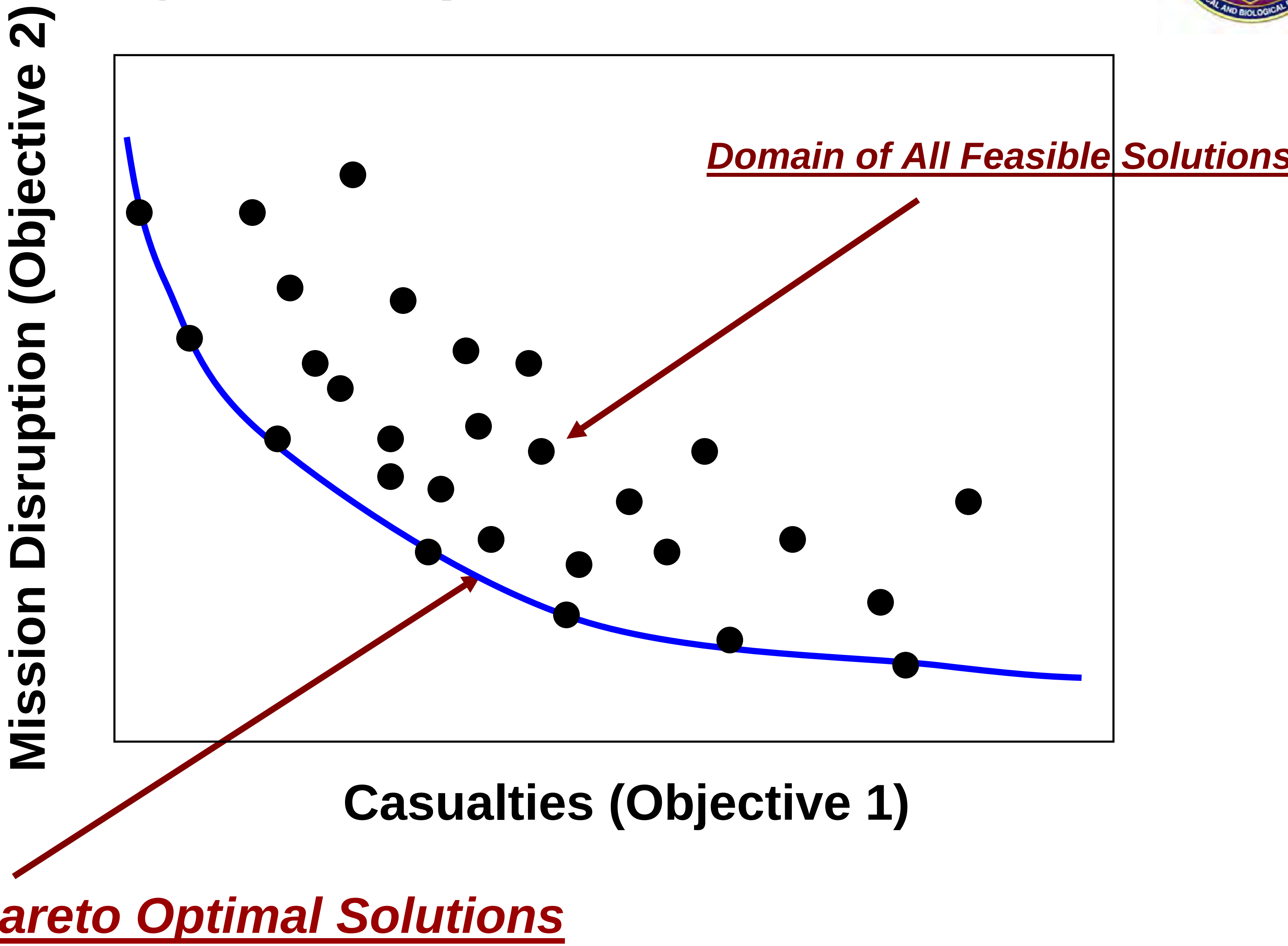
  - ***Multiple (three) goals instead of one***

  - ***Dealing with multiple search spaces not one***

  - ***Artificial fixes affect results***

- We are looking for a set of Pareto-optimal solutions

Multi-Objective Optimization



Multi-Objective Optimization Methods

- ***Global criteria method***
  - Require ***target values for the functions***
  - Can incorporate ***weights for preferences***

- ***Hierarchical optimization method***
  - Optimize the ***top priority function***
  - Specify ***constraints*** to ***prevent deteriorating*** the ***optimized function***

- ***Multi-Objective Genetic Optimization (MOGA)***
  - Non-dominated Sorting Genetic Algorithm

Multi-Objective Optimization

Hierarchical Method

- Rank order the objective functions

$$\boxed{f_{j-1}(\bar{x}) \leq \left(1 \pm \frac{\Sigma_j - 1}{100}\right) \cdot f_{j-1}(\bar{x}^{j-1})}$$

-The j-1 function is used as ***constraint in optimizing the jth*** function.

- Σ_j is a ***lexicographic increment %***

– How much error is allowed in losing optimal solution for (j-1) given more optimization in (j)

Multi-Objective Optimization

Global Criterion

- The ***threshold vector*** is defined by

$$f_i^{0} = \left[f_1^{0}, f_2^{0}, f_3^{0} \dots f_k^{0} \right]$$

$$\boxed{f(\bar{x}) = \sum_{i=1}^{k} w_i \left(\frac{f_i^0 - f_i(\bar{x})}{f_i^0} \right)^P}$$

P is ***integer 1 or 2***

w can also be implemented to represent preferences as ***weights***

Multi-Objective Optimization

Non-dominated Sorting Genetic Algorithm (NSGA)

- While similar to GA, NSGA ***sorts the population*** according to ***non-domination principles***.

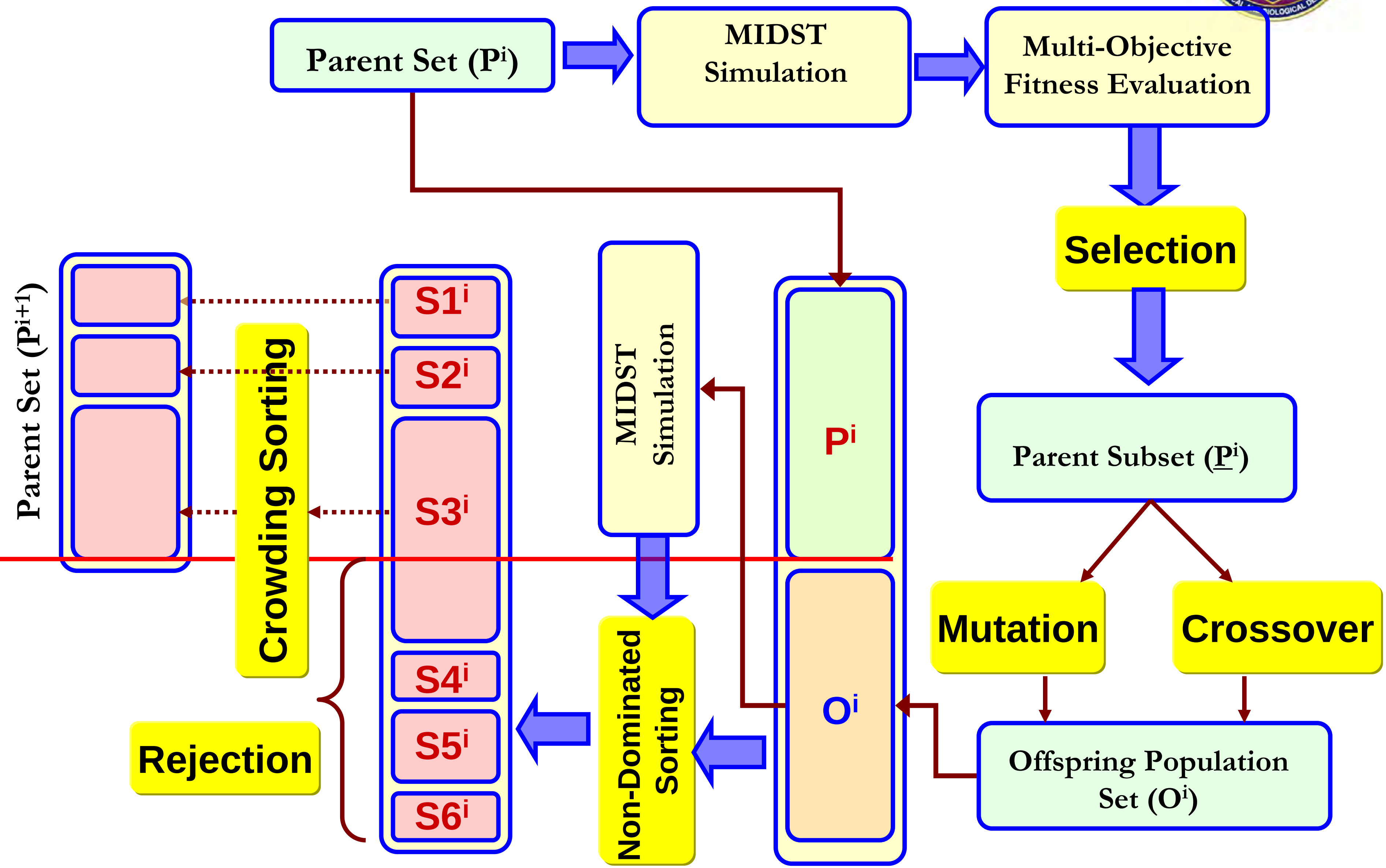
- Population is classified into ***a number of mutually exclusive classes***

- Highest fitness is assigned to ***class*** that are ***closest to the Pareto-optimal front***

- The use of non-dominated sorting ***allows diversity to solutions*** and thus ***guarantees reaching the Pareto-front***.

-***NSGA*** also includes ***elitism principles*** which allows it to find higher number of Pareto-solutions.

NSGA-II



Parent Set (P^i)
MIDST Simulation
Multi-Objective Fitness Evaluation
Selection
Parent Subset ($\underline{P}^i$)
Mutation
Crossover
Offspring Population Set (O^i)
P^i
O^i
MIDST Simulation
Non-Dominated Sorting
$S1^i$
$S2^i$
$S3^i$
$S4^i$
$S5^i$
$S6^i$
Crowding Sorting
Rejection
Parent Set (P^{i+1})

Merits and shortcomings

- ***Derivative based***

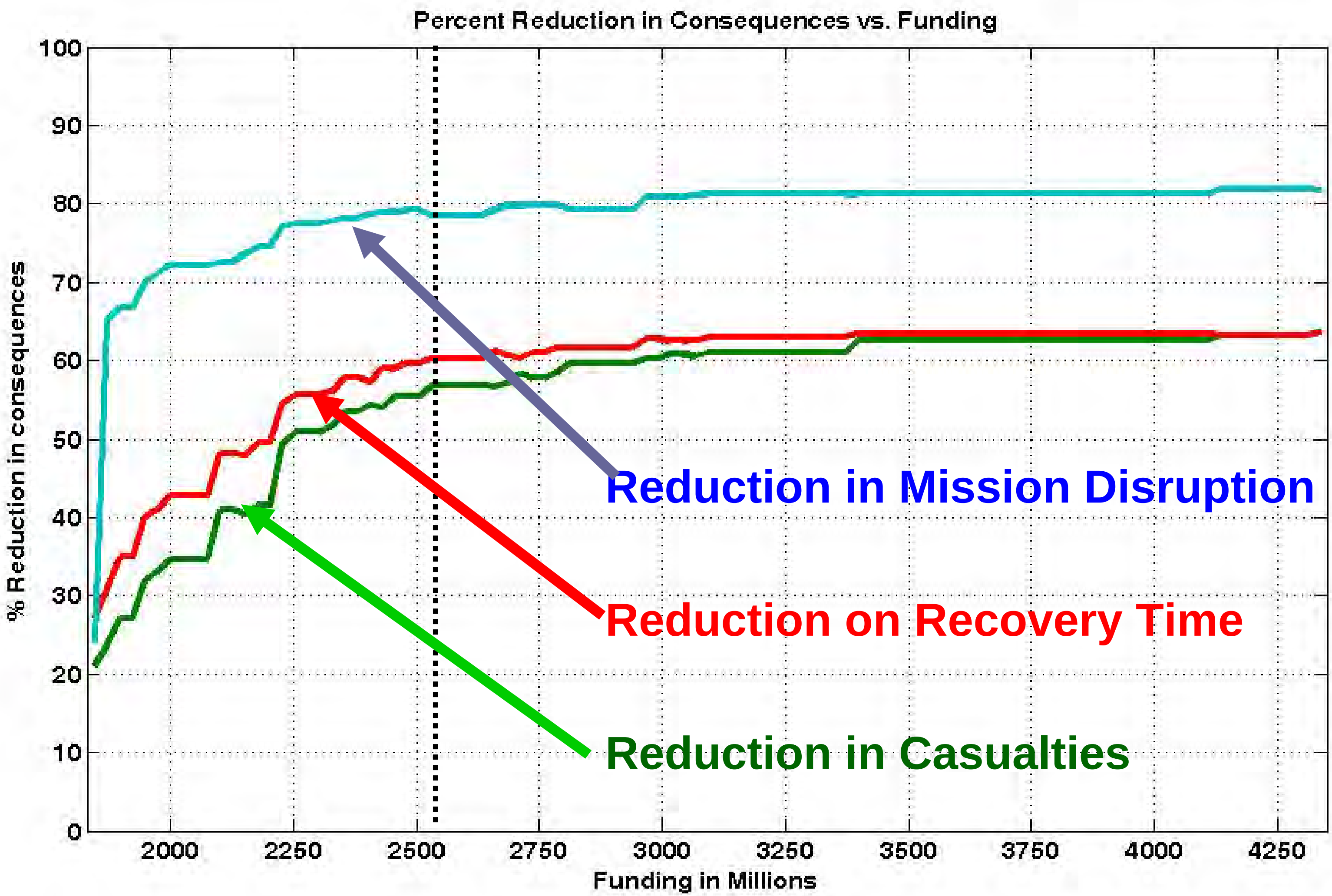
  - If the ***space is continuum***, it converges very fast and an optimal solution is guaranteed
  - If too many ***local minima exist***, the algorithm might be ***trapped*** and ***cannot find global minima***

- ***Non-derivative based***

  - If the ***space is non-continuum***, GA will be able to find the solution
  - Whether ***local minima exist or not***, it will converge.
  - GA is ***better equipped with some aiding optimization*** technique to narrow search domain

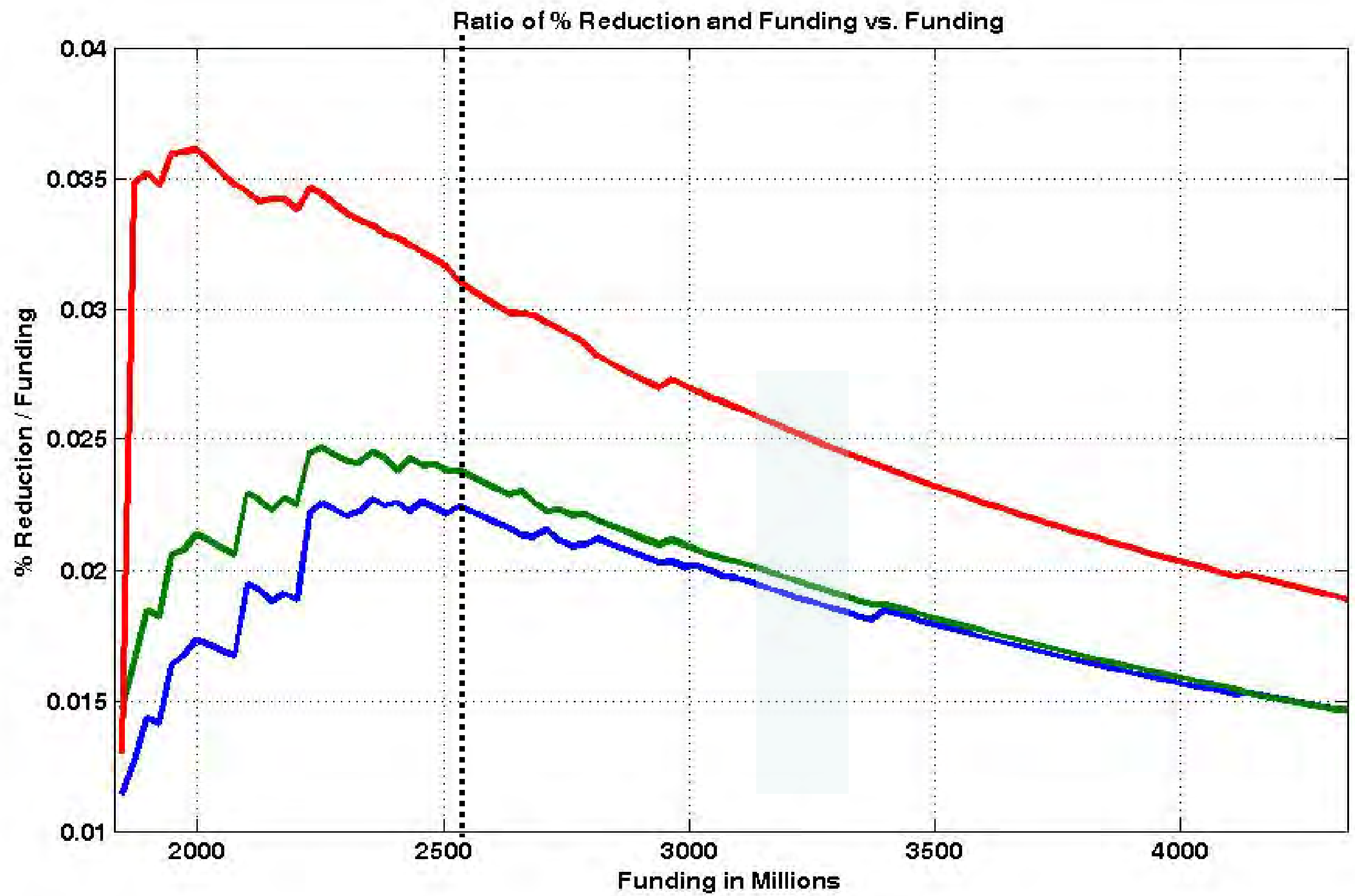
Case study

- For a given group of data cards and inputs we identified



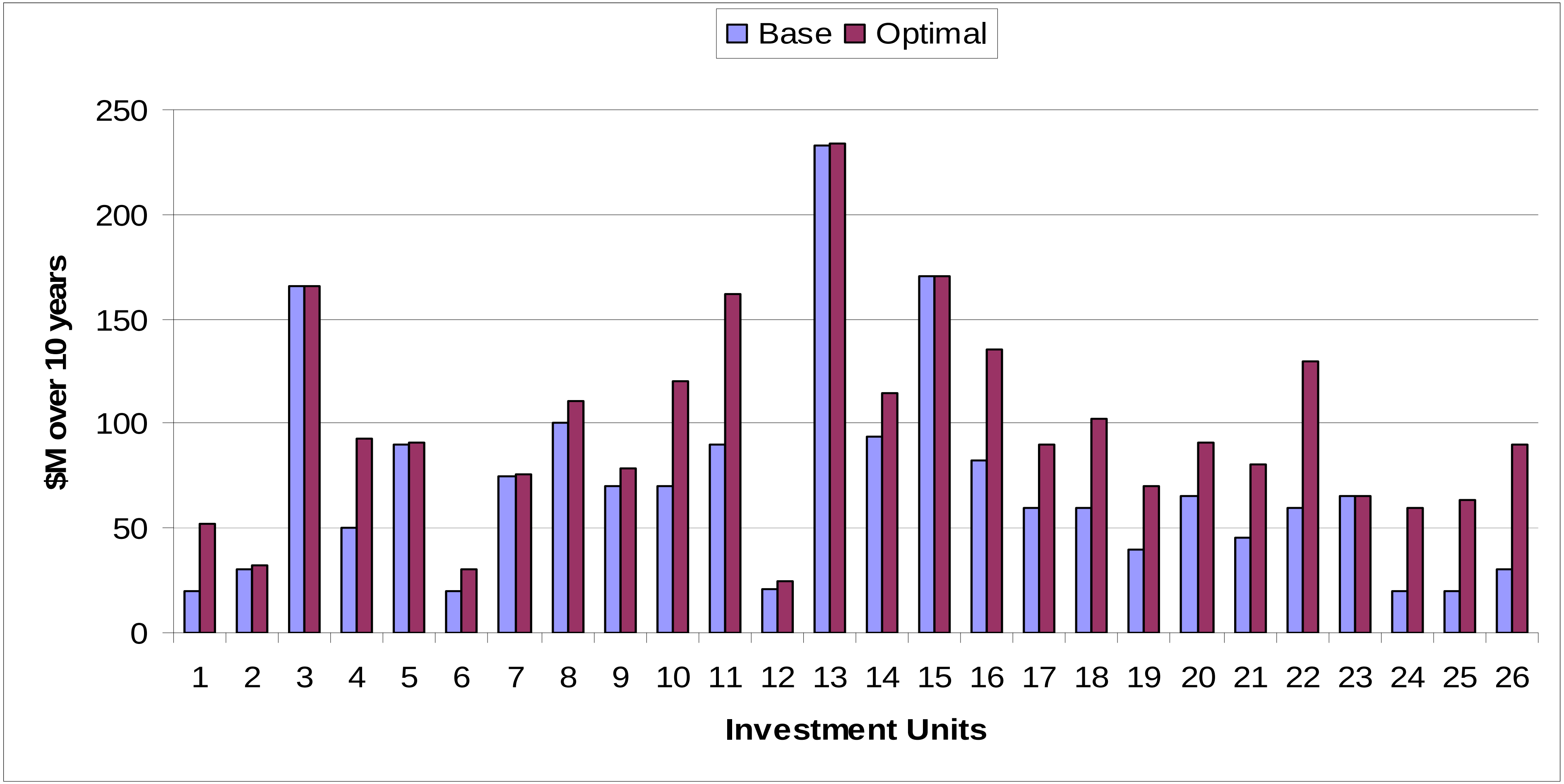
Case study

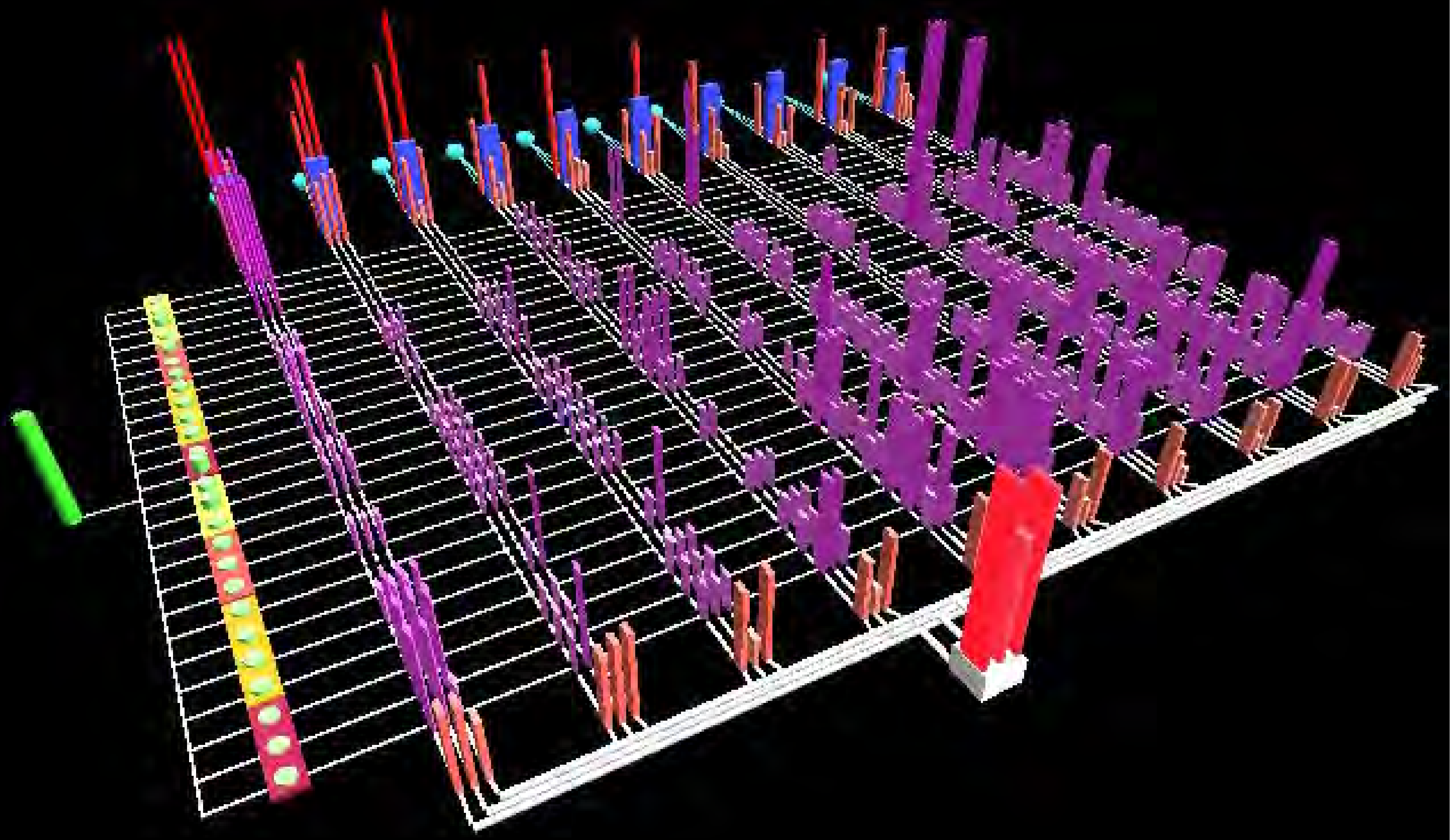
- For a given group of data cards and inputs we identified



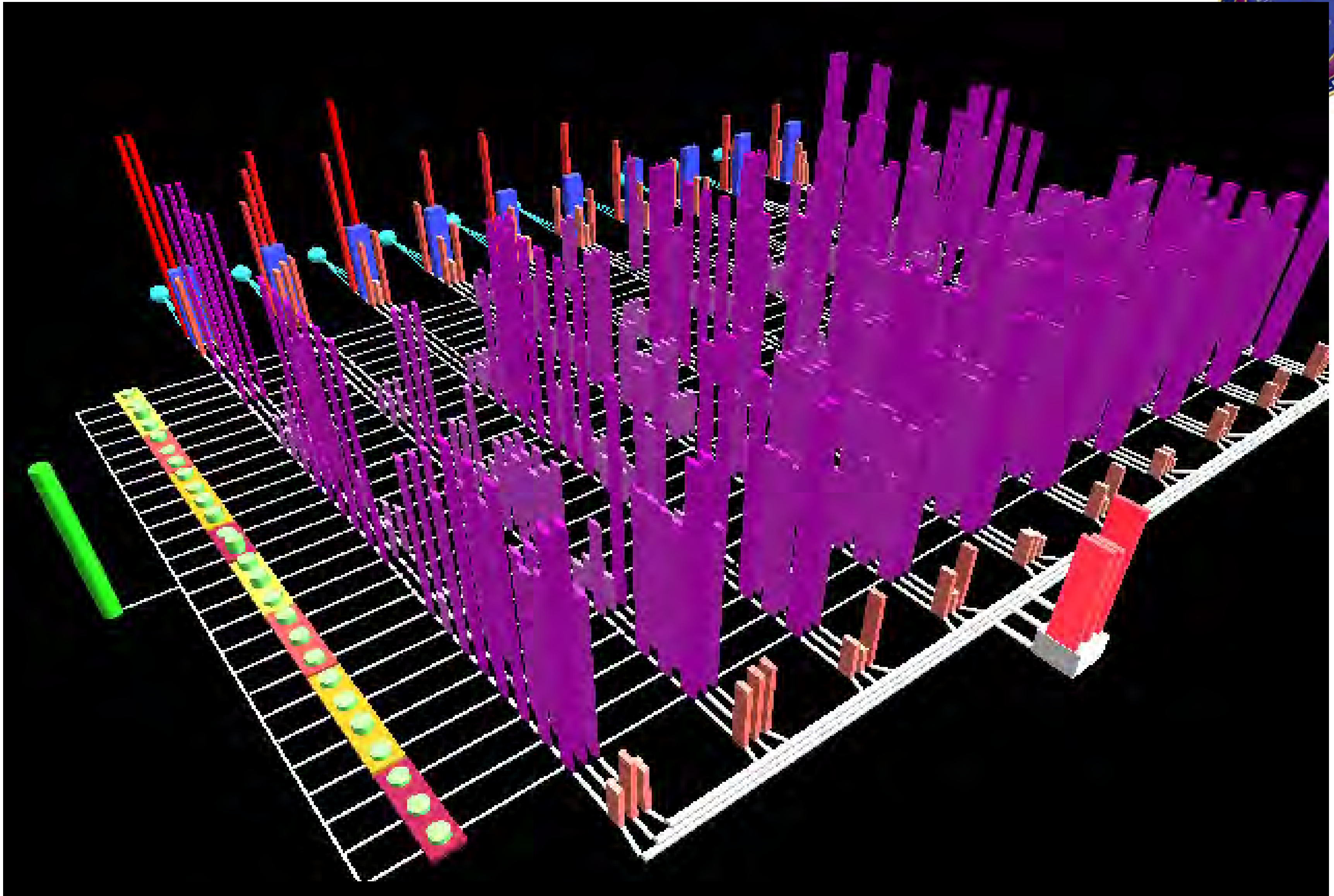
Case study

- At the optimal level, we can identify the funding portfolio





Portfolio for Base Funding $C^1 = 21$, $C^2 = 21$. $C^3 = 42$



<u>Portfolio for Optimal Funding $C^1 = 11$, $C^2 = 12$. $C^3 = 12$</u>

Conclusions

-We demonstrated the possible use of multi-objective genetic optimization for allocation of funding for investment units to reduce consequences of CB events

- Classical gradient based versus gradient free optimization techniques have been examined in search for Pareto solutions

- The presented work is part of MIDST: A robust mathematical framework that can be used to help decision makers for funding allocations considering multiple objectives and priorities

Research is currently on-going to integrate fuzzy rank ordering module as part of the optimization process.

Acknowledgment

This research is funded by

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The authors gratefully acknowledge this funding.

Questions

Derivative-based optimization

Gradient descent method

- Assumes ***continuous*** and ***differentiable function***

$$\theta_{new} = \theta_{old} + \eta G g$$

-g is the derivative of the objective function

$$g(\theta) = \nabla E(\theta) = \left[\frac{\partial E(\theta)}{\partial \theta_1} \quad \frac{\partial E(\theta)}{\partial \theta_2} \quad \dots \quad \frac{\partial E(\theta)}{\partial \theta_n} \right]^T$$

- G is a positive definite matrix

- η is the step size

Derivative-based optimization

Levenberg-Marquardt (LM) method

- A ***modified version of classical Newton's method***. It also assumes ***continuous*** and ***differentiable function***

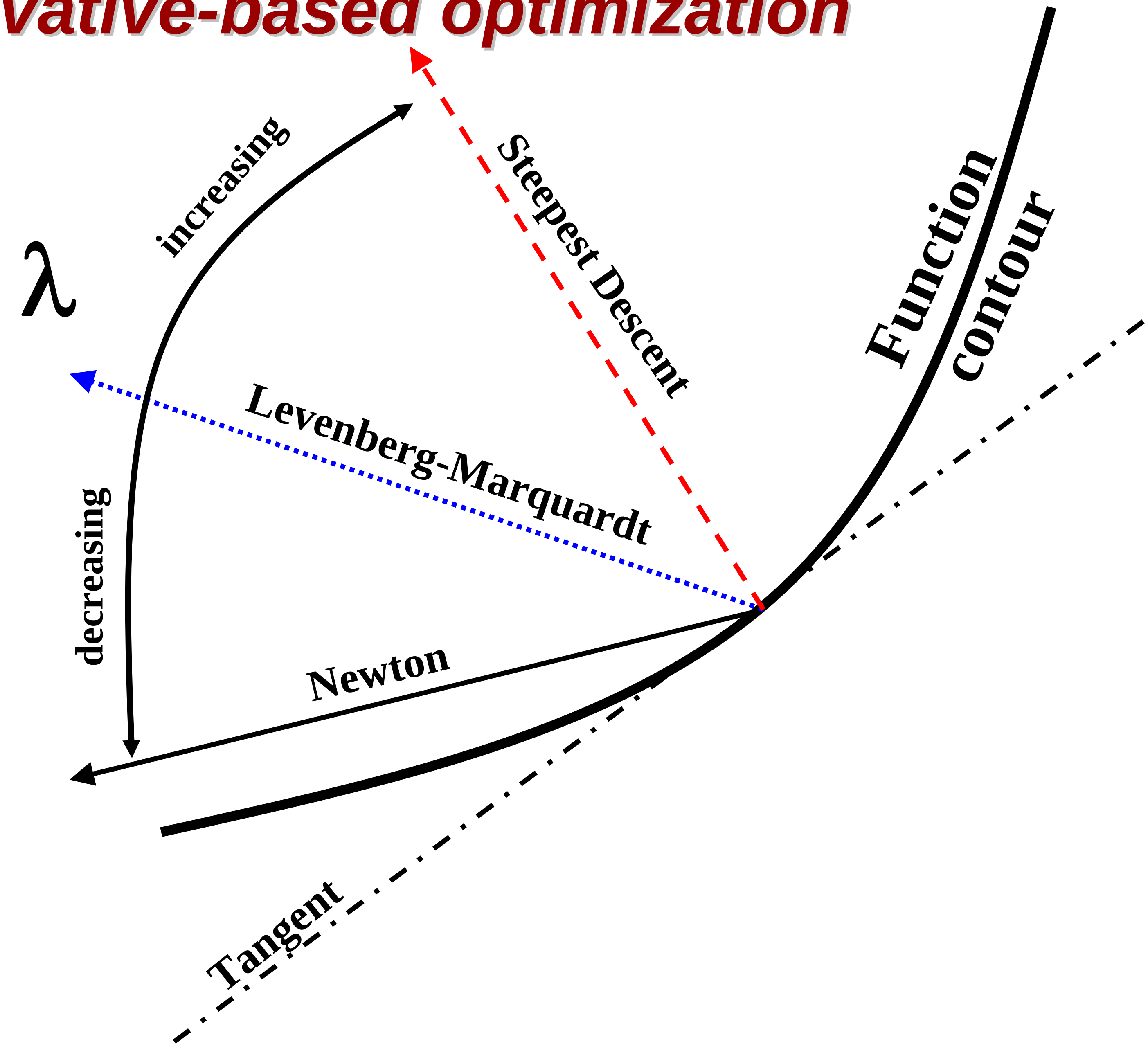
$$\theta_{new} = \theta_{old} - \eta \left(H + \lambda I \right)^{-1} g$$

- g is the gradient, I is the identity matrix, ***λ is some nonnegative value and H is the Hessian matrix***

$$H(\theta) = \nabla^2 E(\theta) = \left[\frac{\partial^2 E(\theta)}{\partial \theta_1^{\,2}} \quad \frac{\partial^2 E(\theta)}{\partial \theta_2^{\,2}} \quad .... \quad \frac{\partial^2 E(\theta)}{\partial \theta_n^{\,2}} \right]^T$$

– η is the step size as defined before

Derivative-based optimization



BROOM

Building Restoration Operations Optimization Model

Enhancing response

Mitigating risks

Accelerating recovery

A chemical or biological release in a critical facility would be devastating

- Severe economic, sociological, and/or security impact if closed for even short periods
  - Military Bases
  - Major Airports
  - Government Facilities
- Challenges facing rapid restoration and recovery
  - Interior Sample Design
  - Interior Sample Collection
  - Sharing Data
  - Visualization
  - Interpretation / Analysis

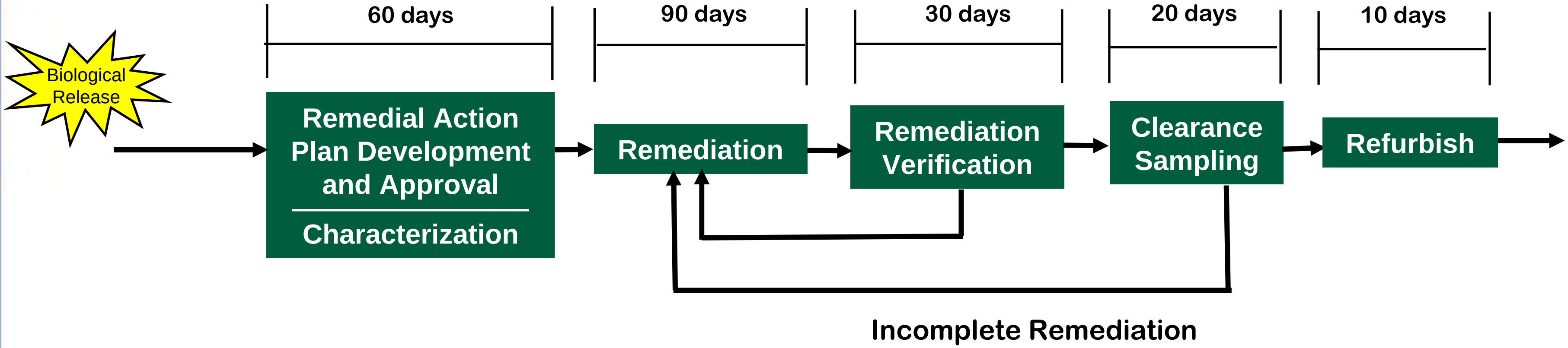
2001 Anthrax Letters

- Postal facilities, senate buildings, and news organizations were contaminated
- Very little experience decontaminating large indoor facilities
- CDC reports that over 125,000 samples were tested at LRN laboratories costing $25-30 mil.
- Many facilities were closed for years and restored at great cost
  - Capitol Hill (4 mo, $42 mil.)
  - Brentwood (26 mo, $130 mil.)
  - US Postal Facilities (3+ yr, $800M)

HOMELAND SECURITY

Accelerating recovery

Previous Restoration Activities

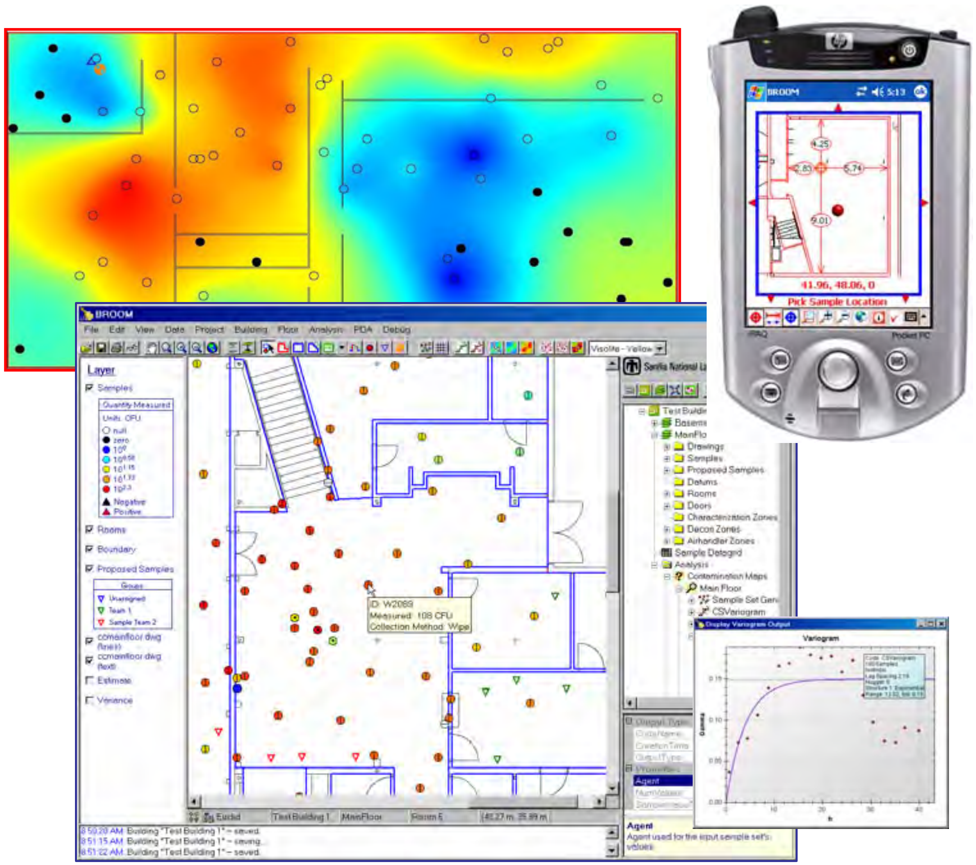


Environmental sampling is a significant component of the restoration and recovery process. Improvements will…

Reduce recovery time and enhance decision making

Integrated Solution

- Planning
- Electronic Data Collection
- Data Management
- Visualization
- Interpretation
- Analysis



Accelerating recovery

Why is integration important?

- Save Time and Money
  - Load floor plans into database
  - Carry out large scale sampling plans
  - Effortlessly transfer field data
  - Automatically chain of custody
  - Results/maps quickly displayed
  - Take fewer samples

- Improve Data Quality
  - Indoor laser positioning
  - No transcription errors
  - Ensure the right data is collected

- Easily Share Data and Analyses
  - Central Relational Database

What is BROOM?

Software to improve the efficiency of restoration operations and enhance decision making

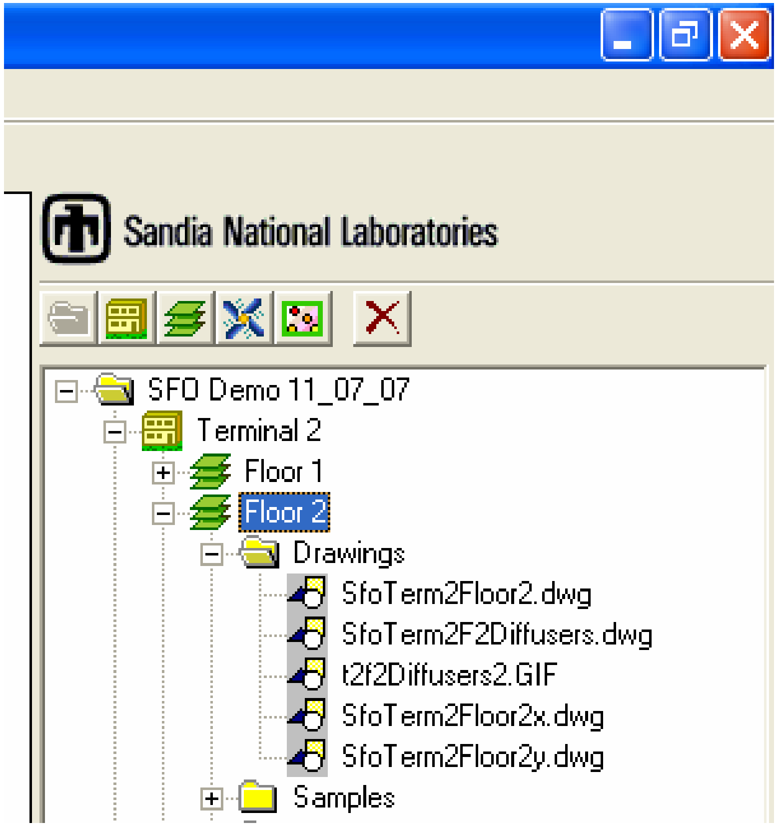
- Desktop
  - Design Sampling Plans
  - Access Sampling Results
  - 2D and 3D Visualization
  - Contamination Maps
  - Confidence Maps
- PDA
  - Display Facility Floor Plan
  - View Sampling Plan
  - Collect Surface, Bulk, and Filter Samples

HOMELAND SECURITY

Accelerating recovery

Planning

- Organize facility drawings
  - Large facility may have 100's to 1000's drawings
  - Structured way to store and retrieve relevant drawings
  - Remote storage
- Design initial response sampling plans
  - Confirm event
  - Determine extent
  - Define characterization/HVAC zones
  - Sample design tools



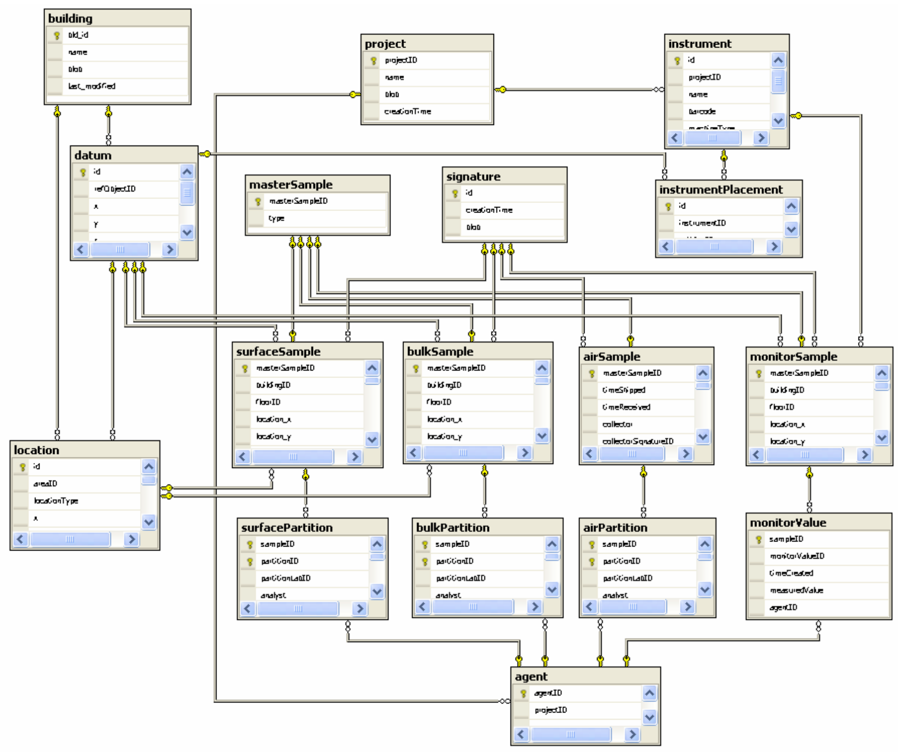
Electronic Data Collection

- Eliminate manual data entry
  - Dealing with many thousands of samples of various types
  - Barcodes improve data tracking
  - Save time and improve accuracy
- Implement sampling plan
  - Download floor plans
  - Display sampling plan
- Accurate position record
  - Integrated laser range finder
- Initiate chain of custody record
  - Save time
  - Improve security

Data Management

Microsoft SQL Server 2005

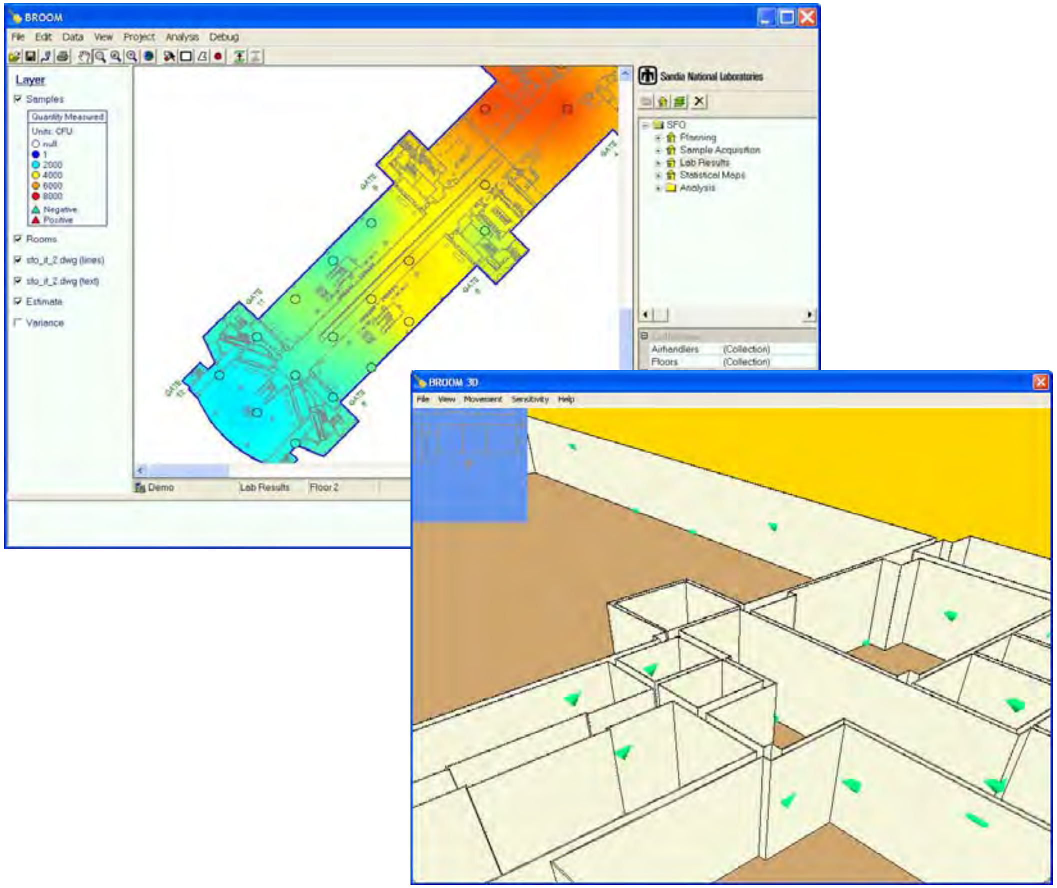
- Relational Database
  - Remote secure access to ALL data
  - Supports multiple concurrent users
- XML Import / Export Utilities
  - Interfaces with analysis laboratories
  - XML is supported by numerous applications



Accelerating recovery

Visualization

- 2D GIS
  - Point and click data retrieval
  - Zoom, pan, rotate
- 3D DirectX
  - View vertical position

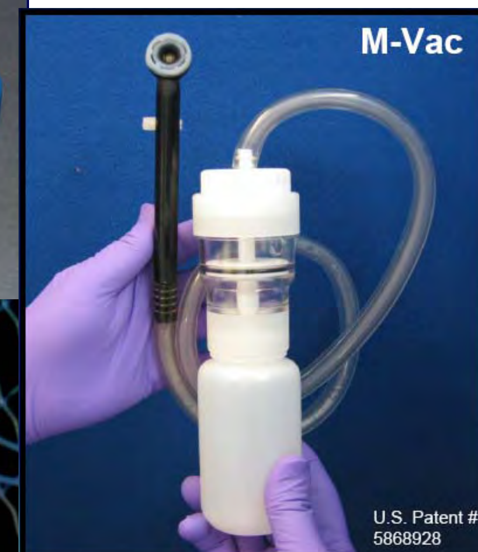


Accelerating recovery

HOMELAND SECURITY

Interpretation

- Use sampling efficiency and collection area to estimate the true surface contamination
  - Able to compare one-to-one samples collected on different surfaces with different methods
  - More precise representation of contamination levels
- Database maintains known collection, extraction, detection efficiencies

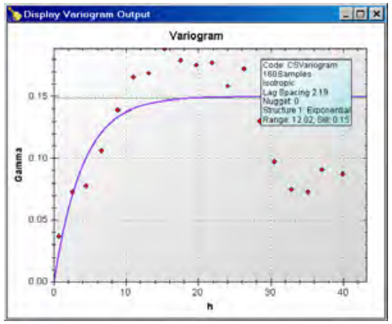


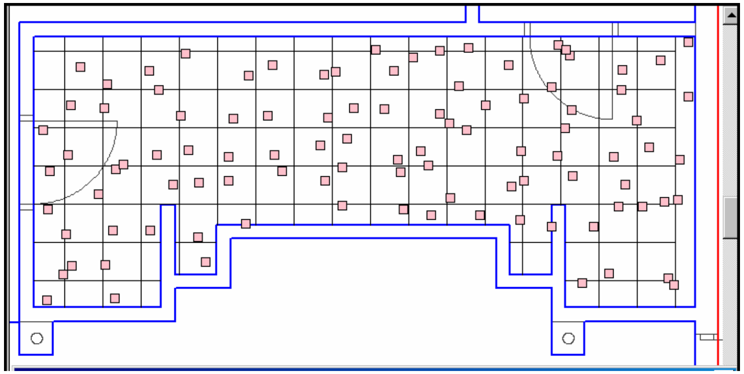
HOMELAND SECURITY

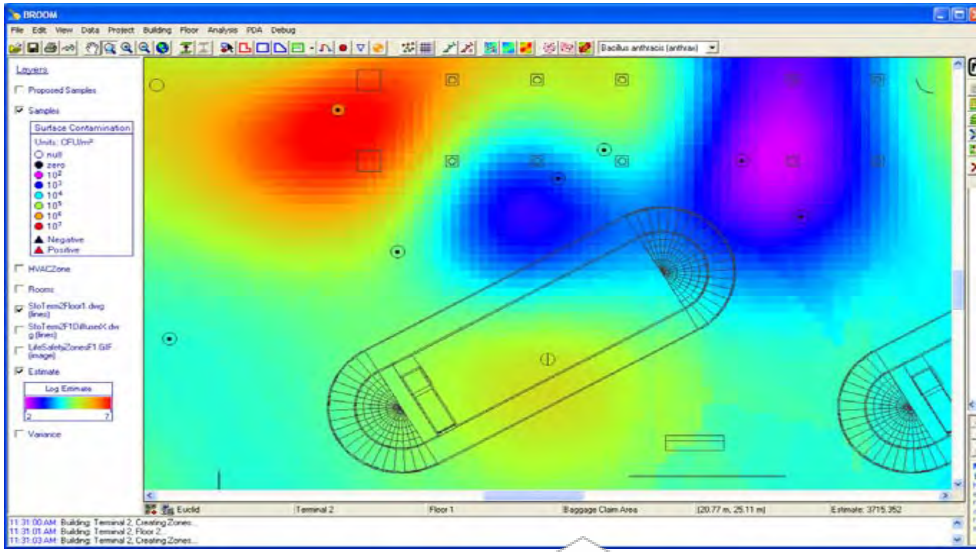
Accelerating recovery

Analysis

- Sample Design
  - Random
  - Grid
  - Visual Sample Plan
- Statistics
  - Min, max, mean, σ, σ^2
  - Histogram
  - Spatial
- Mapping
  - Inverse Distance
  - Kriging
    - Ordinary
    - Indicator
- Advanced Topics
  - Acceptance Models
  - Optimized Design
  - Shortest Path Kriging
  - GeoReferencing



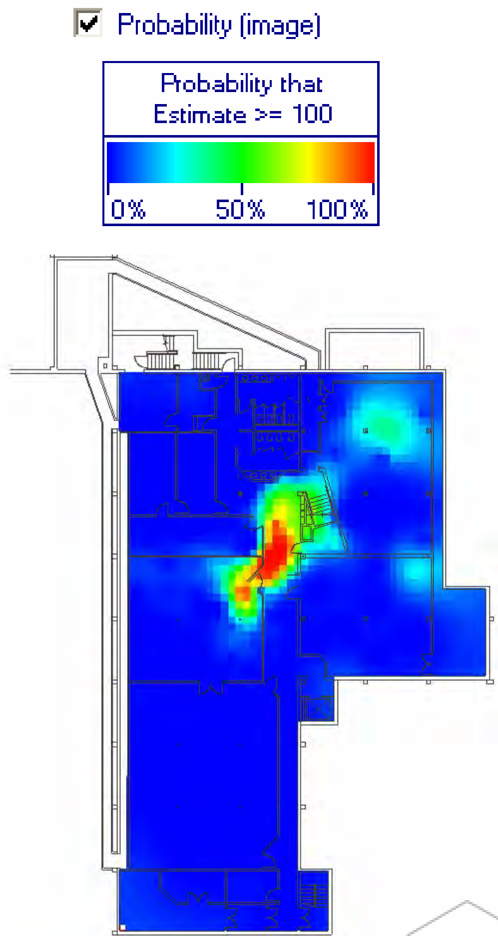


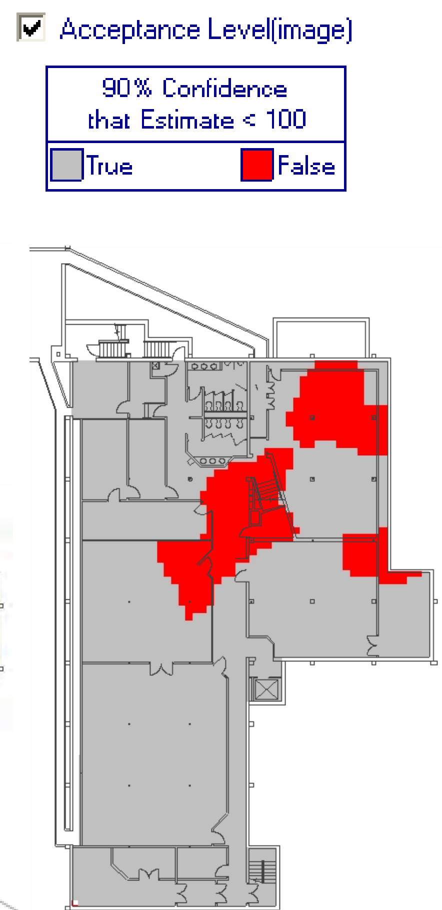


Accelerating recovery

Acceptance Modeling

- Determine the probability of exceeding a specified threshold
  - Local mean (estimate)
  - Kriging variance
  - Normal score transform
- Display where the threshold level is met to a given degree of confidence.



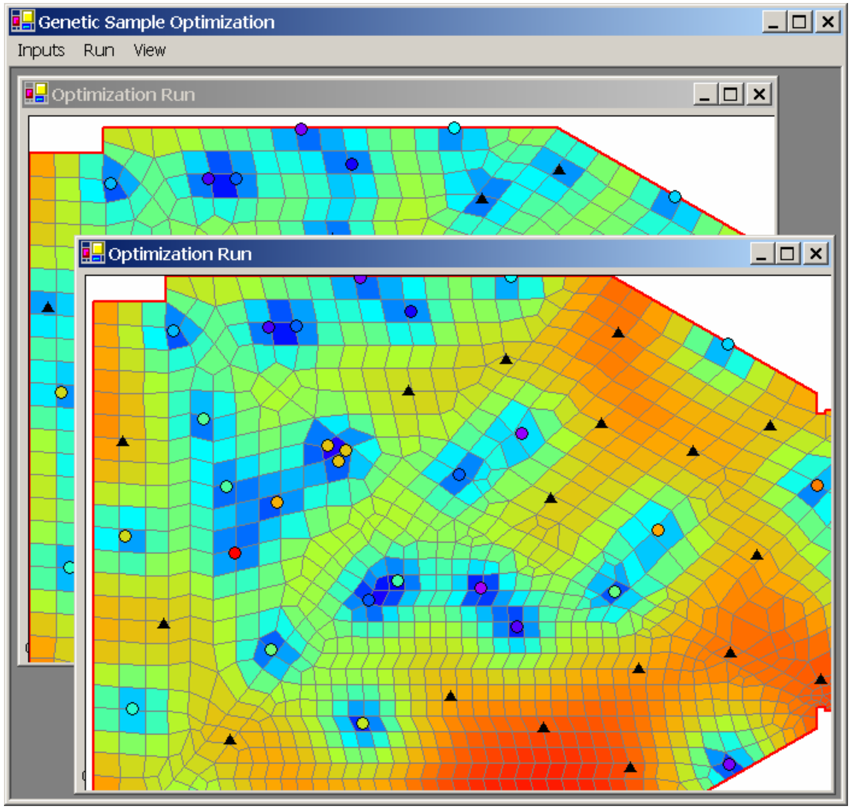


Accelerating recovery

HOMELAND SECURITY

Sample Optimization

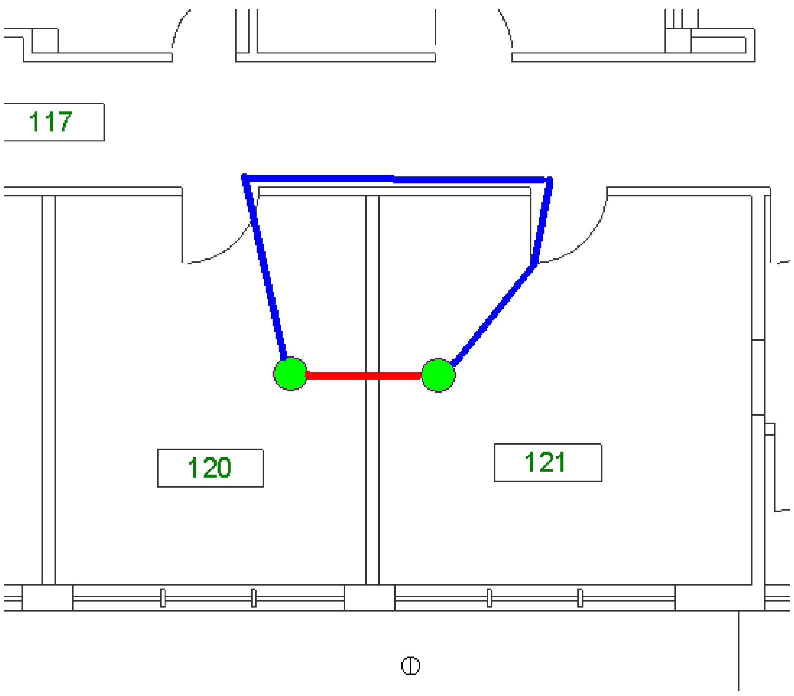
- Objectives
  - Minimize overall uncertainty
  - Target specific threshold
  - Target hotspots



Accelerating recovery

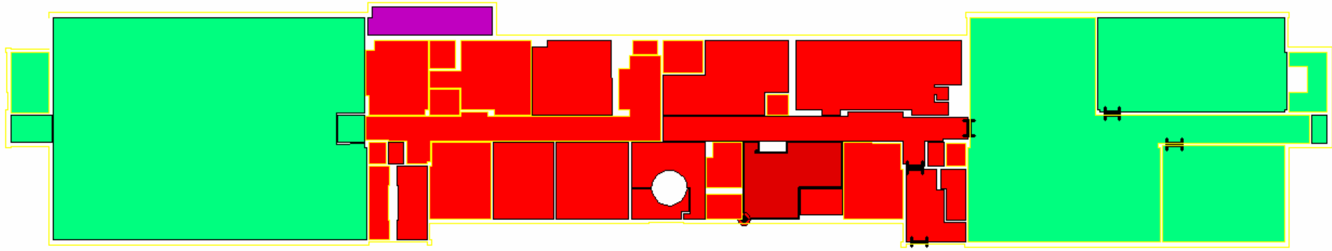
Shortest Path Kriging

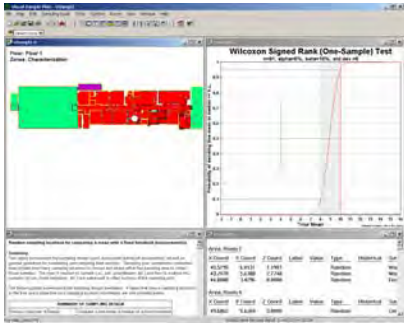
- Modified ordinary kriging
- Distance between two points is the shortest travel distance taking into consideration structural barriers
- Produces better uncertainty estimates and improved contamination maps

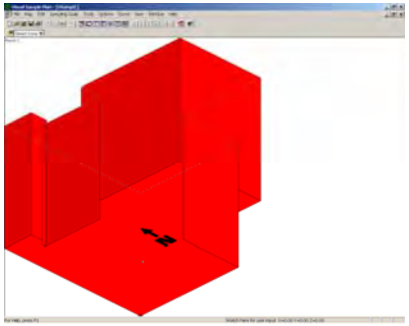


VSP (PNNL) Integration

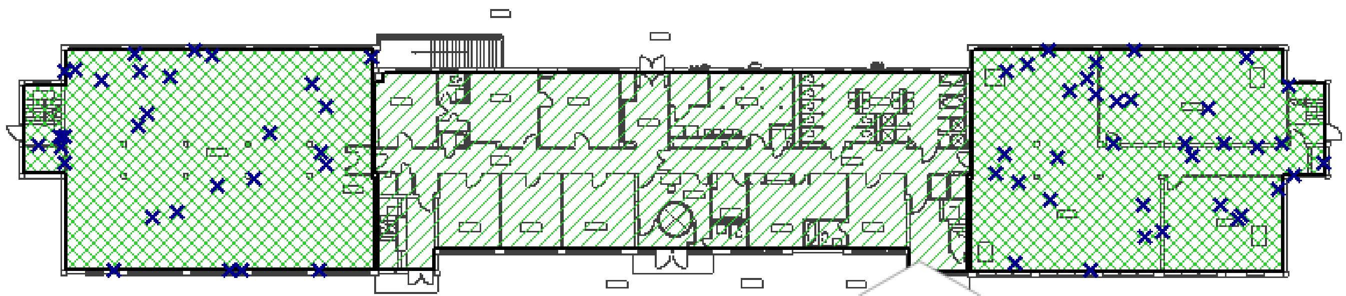
Visual Sample Plan







BROOM



BROOM Field Testing

- **Anniston, AL – Nov ’04**
  - EPA ClO_2 fumigation test
  - BI data management
  - RF positioning test
- **Albuquerque, NM – Jan ’05**
  - BROOM exercise
  - Sandia HazMat sampling team
  - RF/Laser positioning test
- **Albuquerque, NM – Feb ’05**
  - NIOSH/Sandia joint exercise
  - Aerosol release
- **San Francisco Airport – Jan ’06**
  - DHS demo for national audience
  - Sample and BI data management

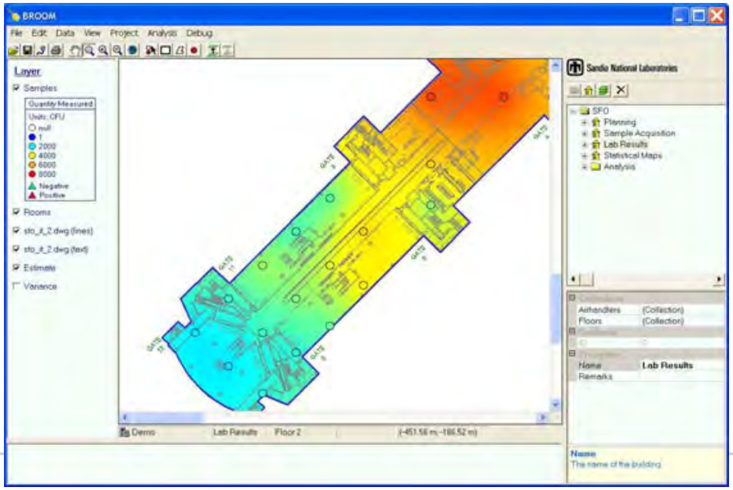
HOMELAND SECURITY

Accelerating recovery

Benefits/Uniqueness

Integrated software package designed to improve end-to-end restoration operations

- Save Time and Money
- Improve Decision Making
- Promote Interagency Sharing



BROOM Contact

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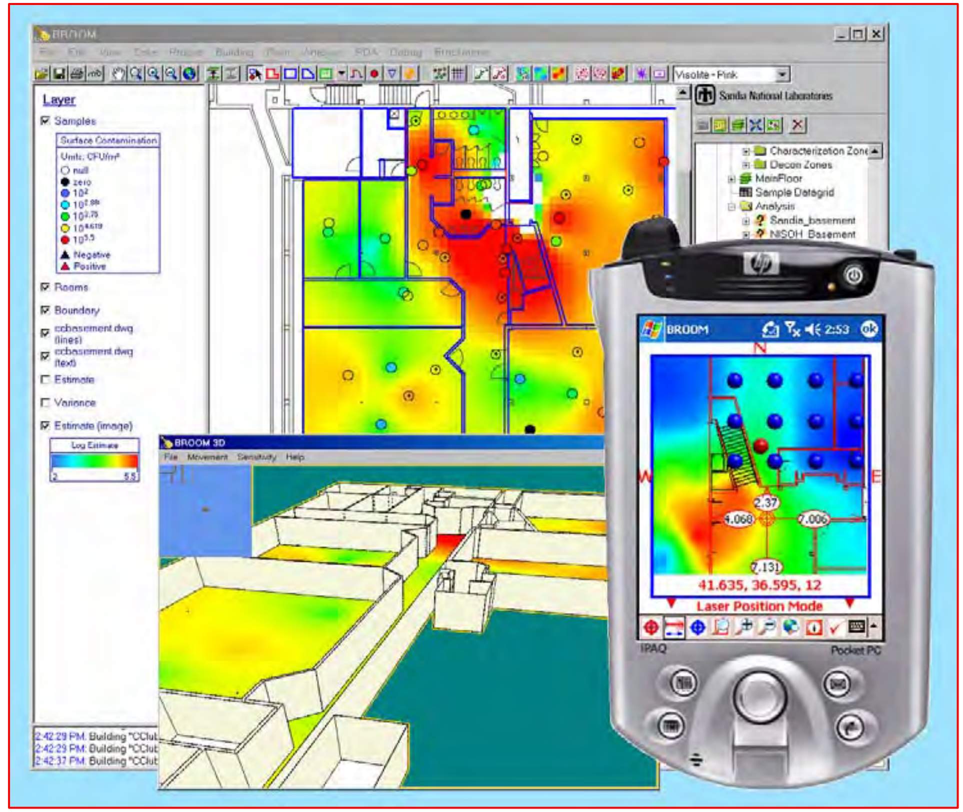


Sandia National Laboratories

HOMELAND SECURITY

Next Generation Chem Bio Battle Management Integrated Information Management System

2007 Chemical Biological Information Systems
Conference & Exhibition
10 January 2007

Jim Reilly
james.reilly@rl.af.mil

Agenda

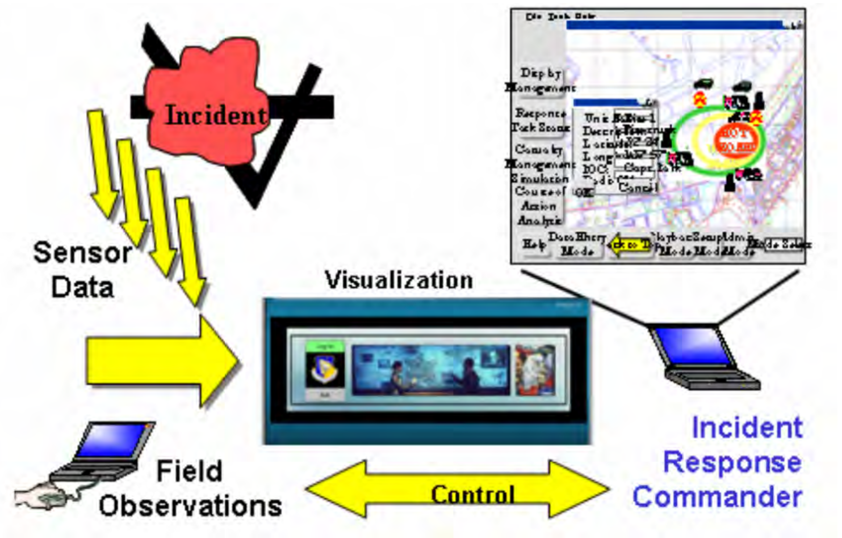
- Favorite slides from the project
  – How we got here
- OODA Loop
  – Data, information and knowledge flow in IIMS
- IIMS Capabilities and Battle Management Issues
- What still needs to be done

Next Generation CB Battle Management

Jim Reilly, AFRL/IFSF

Objective: Develop a program leveraging existing, multi-mission sensors to support a NBC sensor fusion and battle management capability.

Description of Effort: Existing and proposed MASINT sensor systems will be examined and a means developed for tracking and fusing information from passive, active and human data sources used to detect and track chemical and biological attacks. Technologies from the Control of Agent-Based-Systems, Effects Based Operations and the Joint Warning and Reporting Network programs will be used to integrate sensor systems and command and control systems.



Benefit to Warfighter: Warfighting elements will be provided an immediate CB situational awareness, links to sensors, and a capability to disseminate fused information to appropriate decision makers for in-time response to detected threats.

Challenges:
- Representation of sensor data to support automated reasoning
- Handling uncertainty in sensor data in near-real time
- Control of heterogeneous sensors and decision-making systems

Maturity of technology: Advanced Technology Development (6.3)

Business Area: Information Systems Technology

Major goals/milestones by FY:
- FY04: Integration of sensors and reasoning framework
- FY05: Support for management of data uncertainty
- FY06: Delivery and test of initial capability (end-to-end)
- FY07: Delivery and test of enhanced capability (increased #'s of sensors, multiple decision-making threads)

Funding ($K):

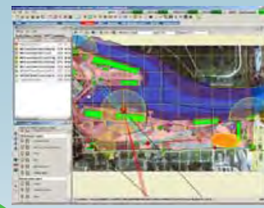
	FY04	FY05	FY06	FY07	Total
6.2	500	700	500	400	2,100

PI Contact Info: Mr. Jim Reilly, AFRL/IFSF, james.reilly@rl.af.mil, DSN 587-3333, 315-330-3333

Battle Management Spectrum

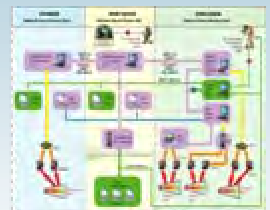
<u>**Fixed Site**</u> **(RestOps)**	<u>**Expeditionary Site**</u> **(CASPOD)**	<u>**Mobile Site**</u>	<u>**Incident Response**</u> **(IMCR)**
Fixed Participants	**Know Participants**	**Know Participants**	**Unknown Participants**
Fixed Infrastructure	**Portable Infrastructure**	**Mobile Infrastructure**	**Any Infrastructure**
Well Defined Mission	**Defined Mission**	**Defined Mission**	**Save Lives**
Train Together	**Coordinated CONOPS**	**Coordinated CONOPS**	**Limited or No CONOPS**
Years to prepare	**Weeks to Prepare**	**Hours to Prepare**	**Hours to Prepare**
Single Platform	**Multiple Platforms**	**Multiple Platforms**	**Any Platform**

The Path followed



2003 RestOps

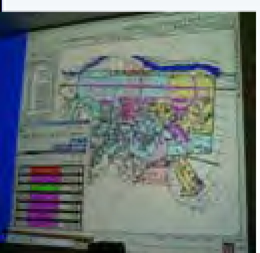
2004 JWID



2004 Beaumont

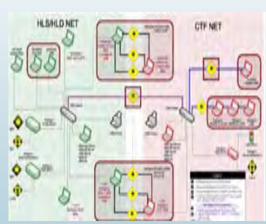
2005 CWID

2005 Kuwait AS



2006 Kuwait KNB

2006 CWID

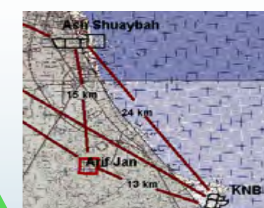


2006 JOEF

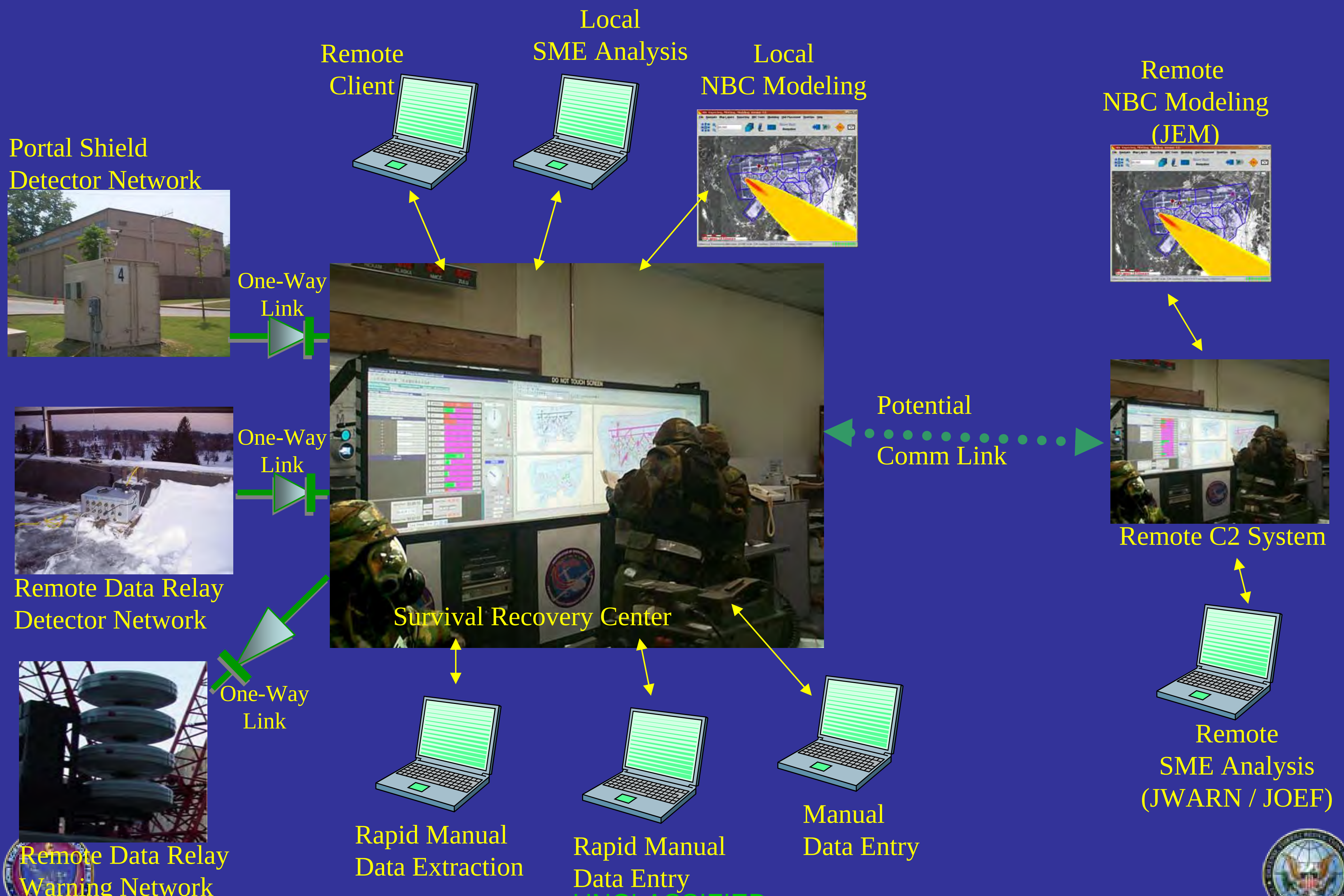
2007 IE-Ku??

2007 CWID

RestOps
CASPOD
NGCBBM
Shared COP
AF 46th TS



Chem/Bio Battle Management

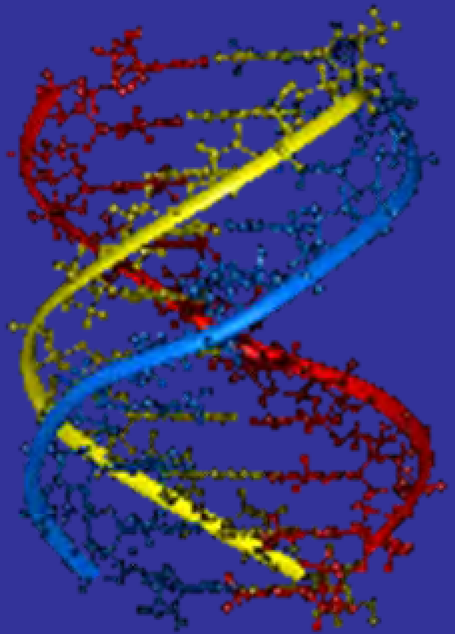


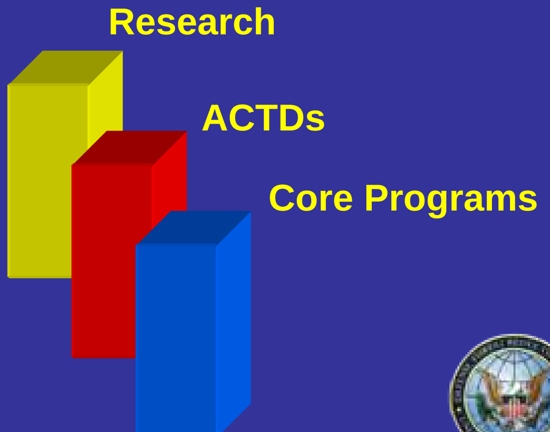
Transitioning Technology to the Warfighter

(Parallel Spiral Development)

- Create a Receptive host for Tech Transition
  - Provide a C2 Backbone for researchers to build against
  - Integrate mature IT products using ACTDs
  - Technically and Operationally Test concepts for Military Utility
  - Transition to either Core Programs or existing Battle Management Systems

- Field technology, solutions, and CONOPs
  - Build on success
  - Add components
  - Provide blue print for NBC Battle Management
  - Generalize the solution to address joint CONOPS
  - CONOPS and Technology leapfrog





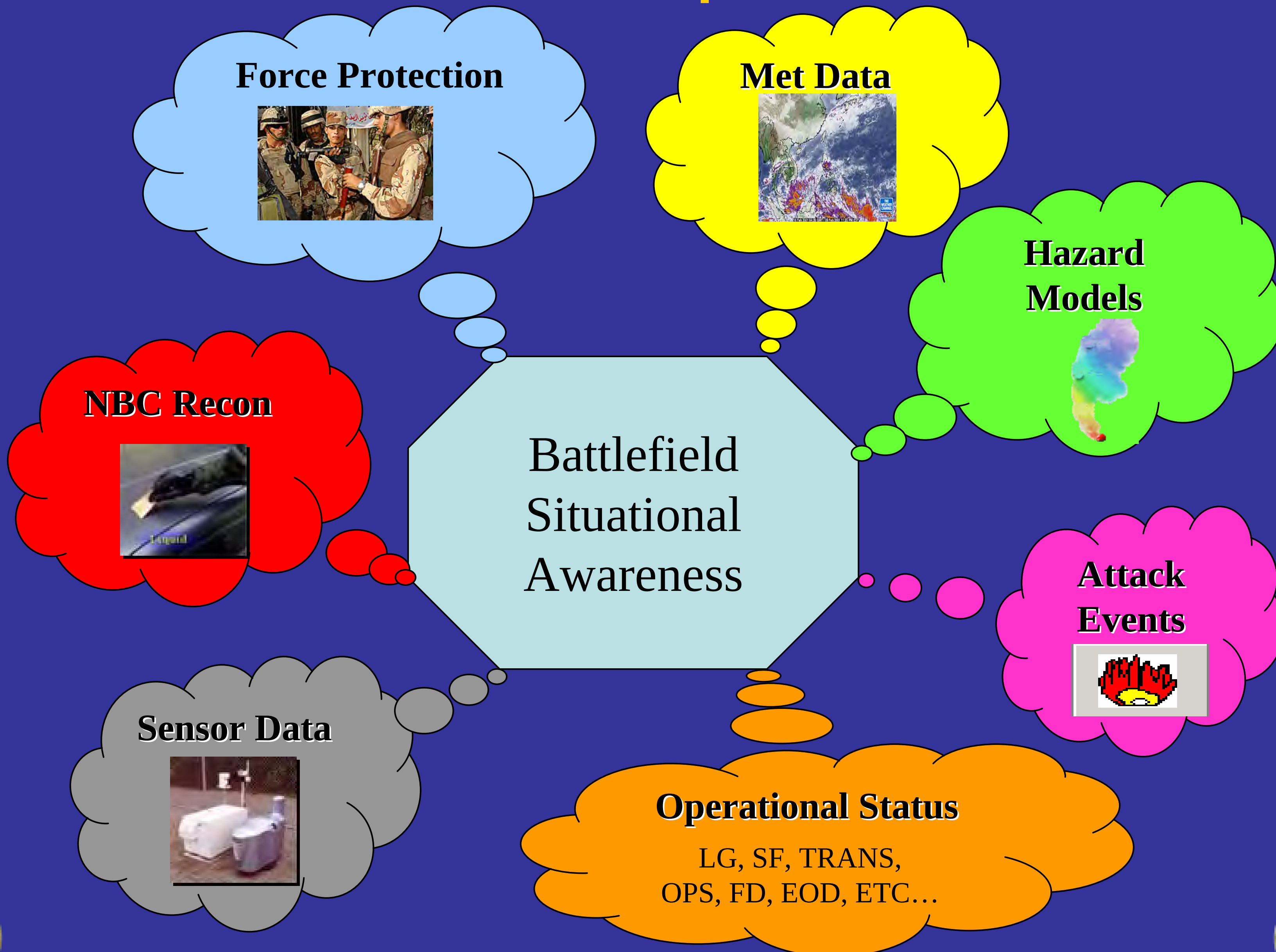
Observe, Orient, Decide and Act Loop

Data, information and knowledge flow in IIMS

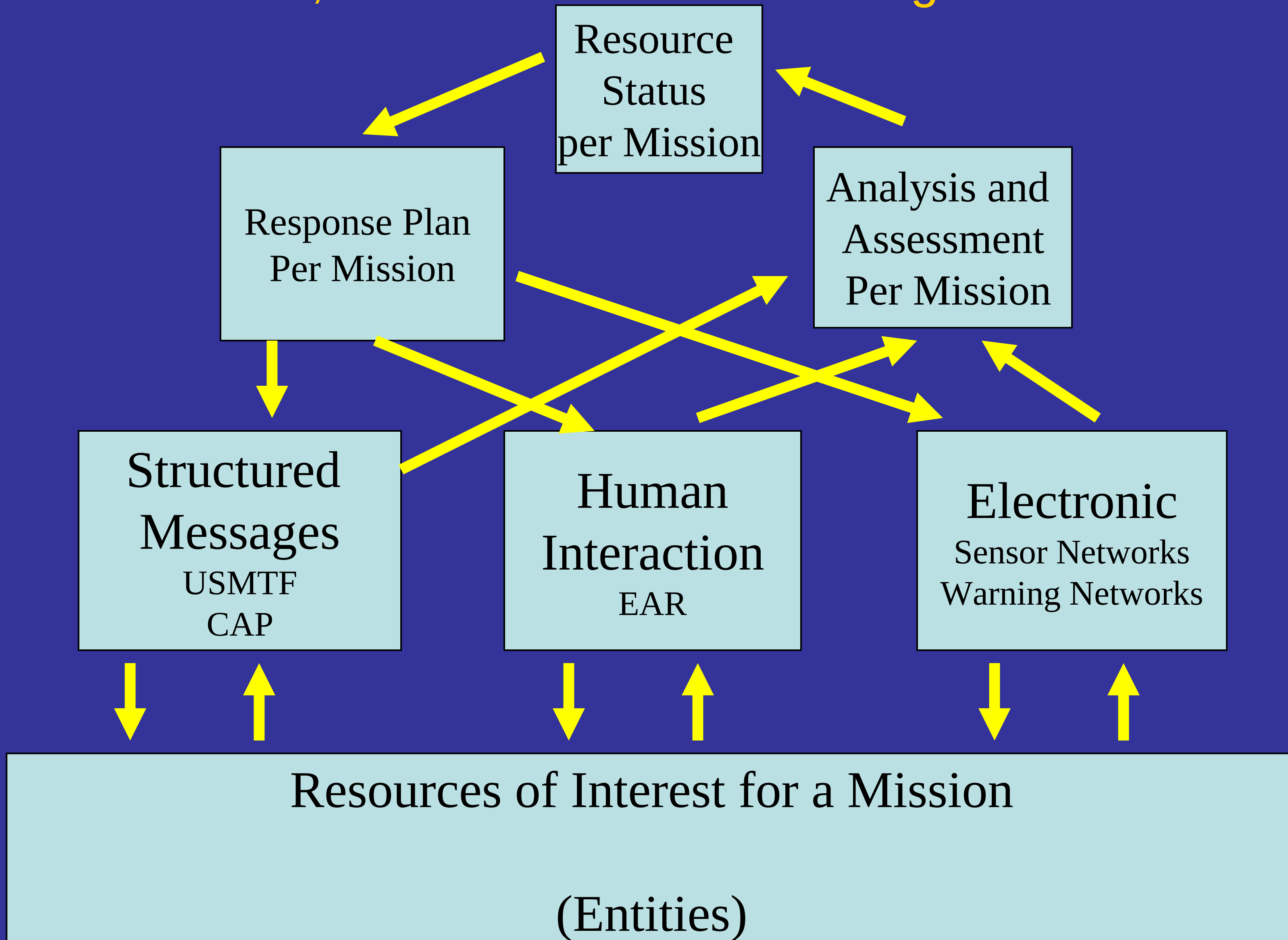
CBRN
Battle Management Questions

- What is it?
- Where is it?
- What is the impact on missions?
- How long will impact last?
- What will change the extent, degree or length of impact?
- What confirms/contradicts a change in impact?

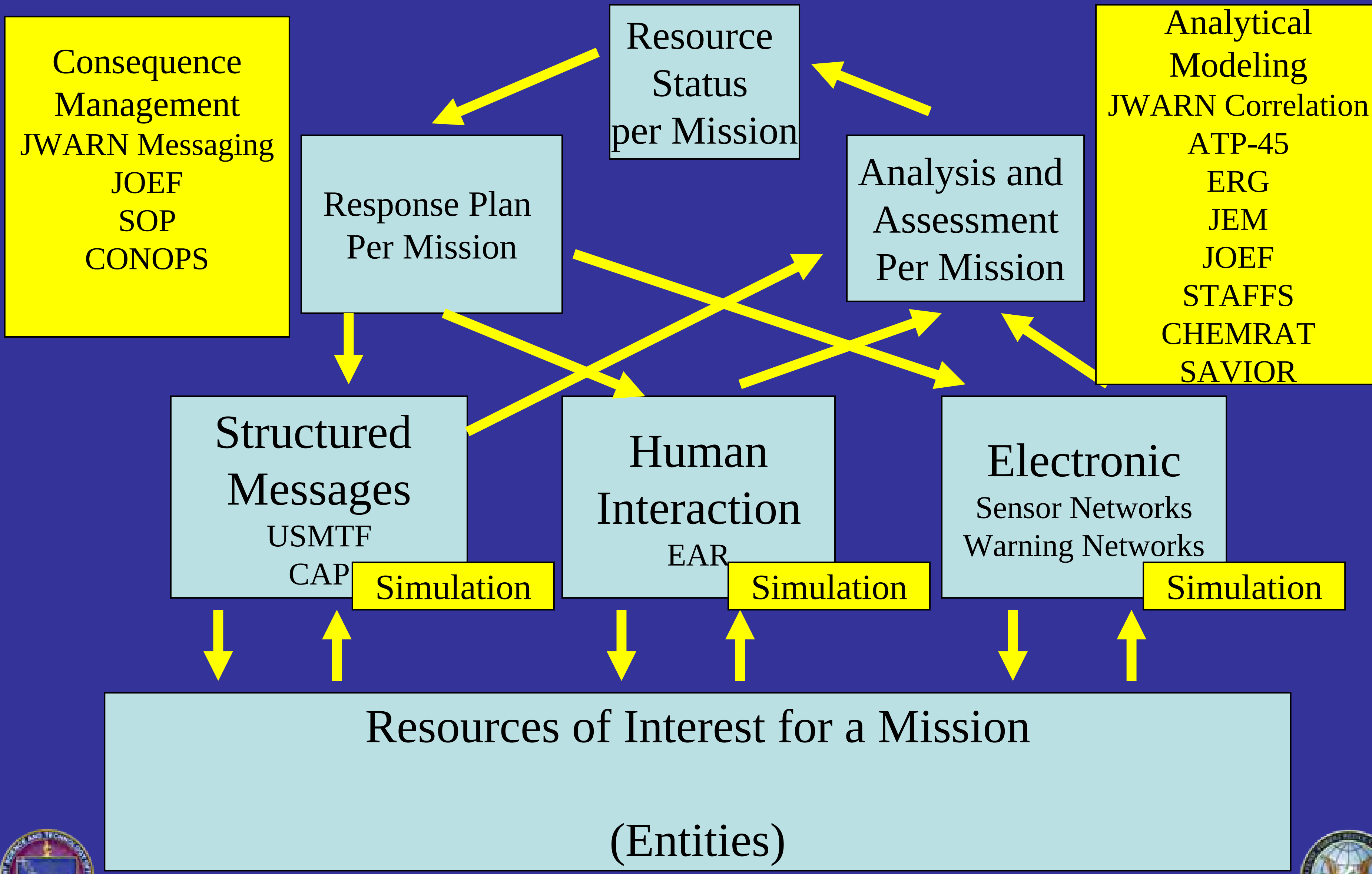
Battle Space



Battle Management
Data, Information and Knowledge Flow

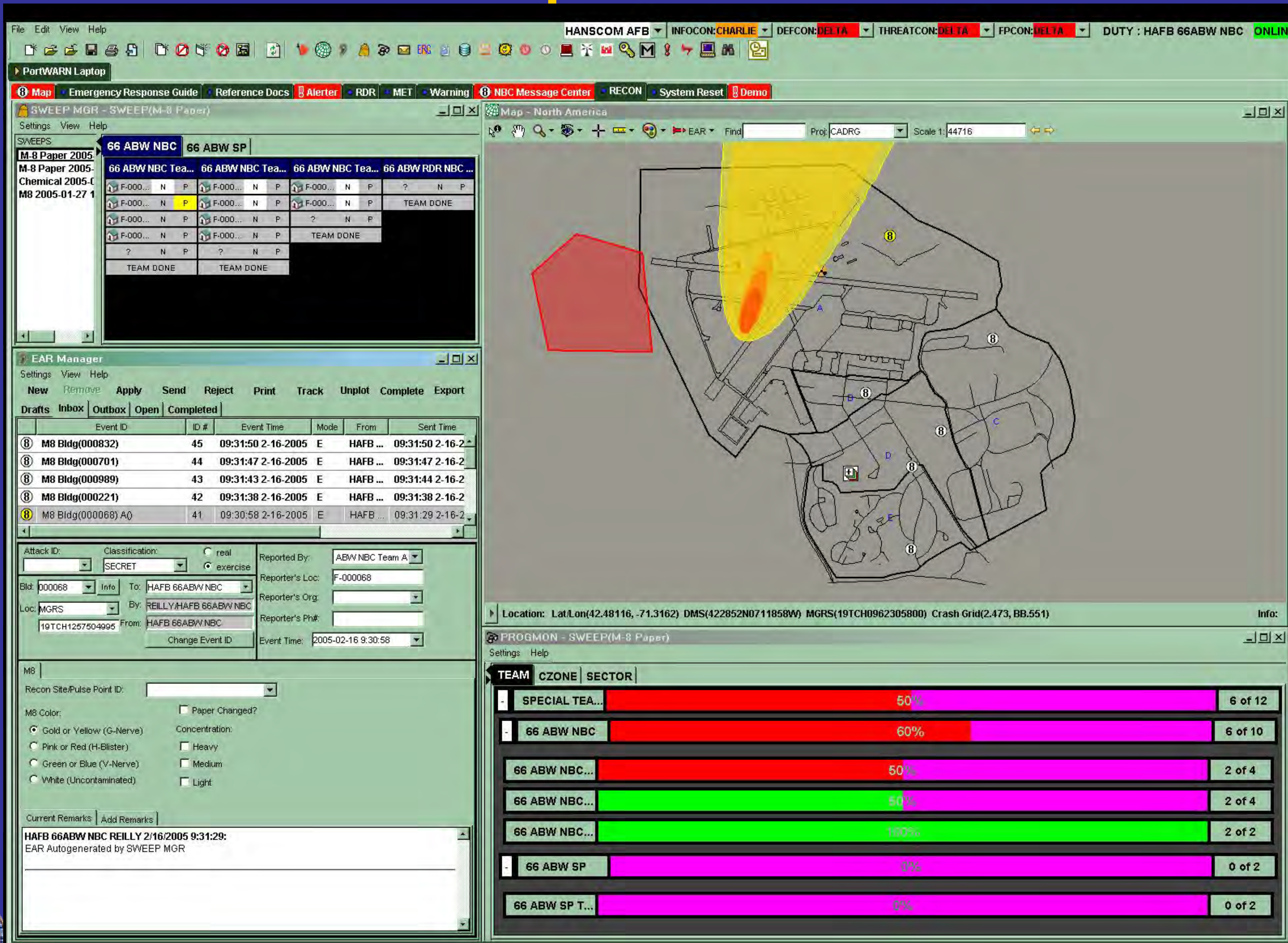


Battle Management
Data, Information and Knowledge Flow



IIMS Capabilities
and
Battle Management Issues

Sweep Interface



Information Extraction

http://66.15.194.217 - Patrol Leader Portal :: Standard Patrol Debriefing Report - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Patrol Leader Portal

Log out

Standard Patrol Debriefing Report

Staff Sergeant John Lewis
3rd Platoon, B Company 1st Battalion, 3rd Marines

Debriefing Reports | Tactical Reference | Alerts

PATROL REPORT SUMMARY
Click on question number to modify answer.

A. Size & Composition of Patrol

1. How many personnel were in your patrol?
45

2. How many vehicles?
6

3. List the elements that composed your patrol and the number of persons in each
Assault-10, Support-20, Security-16

B. Tasks (mission)

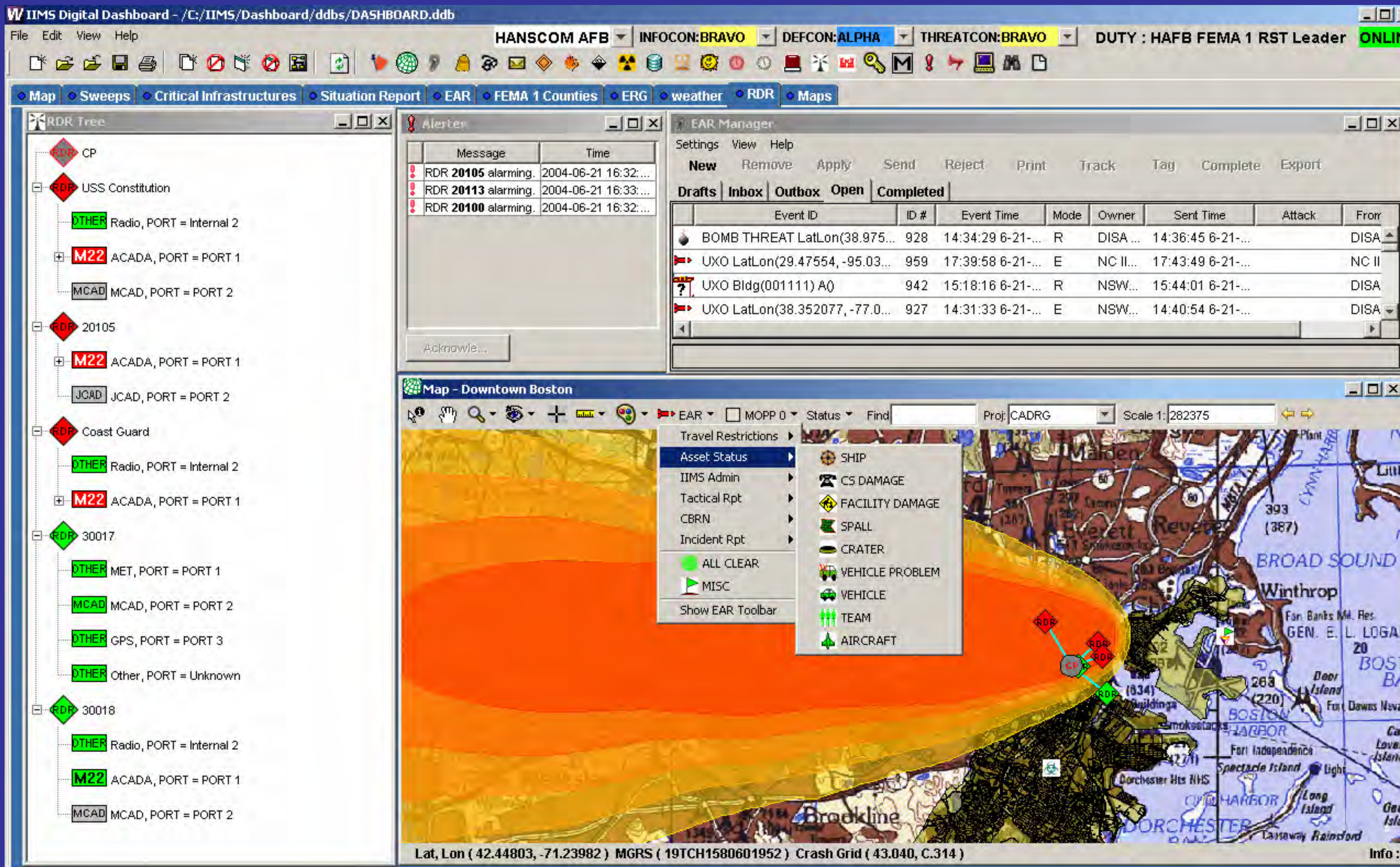
4. What type of patrol did you conduct?
Combat

5. What type of combat patrol did you conduct?
Security

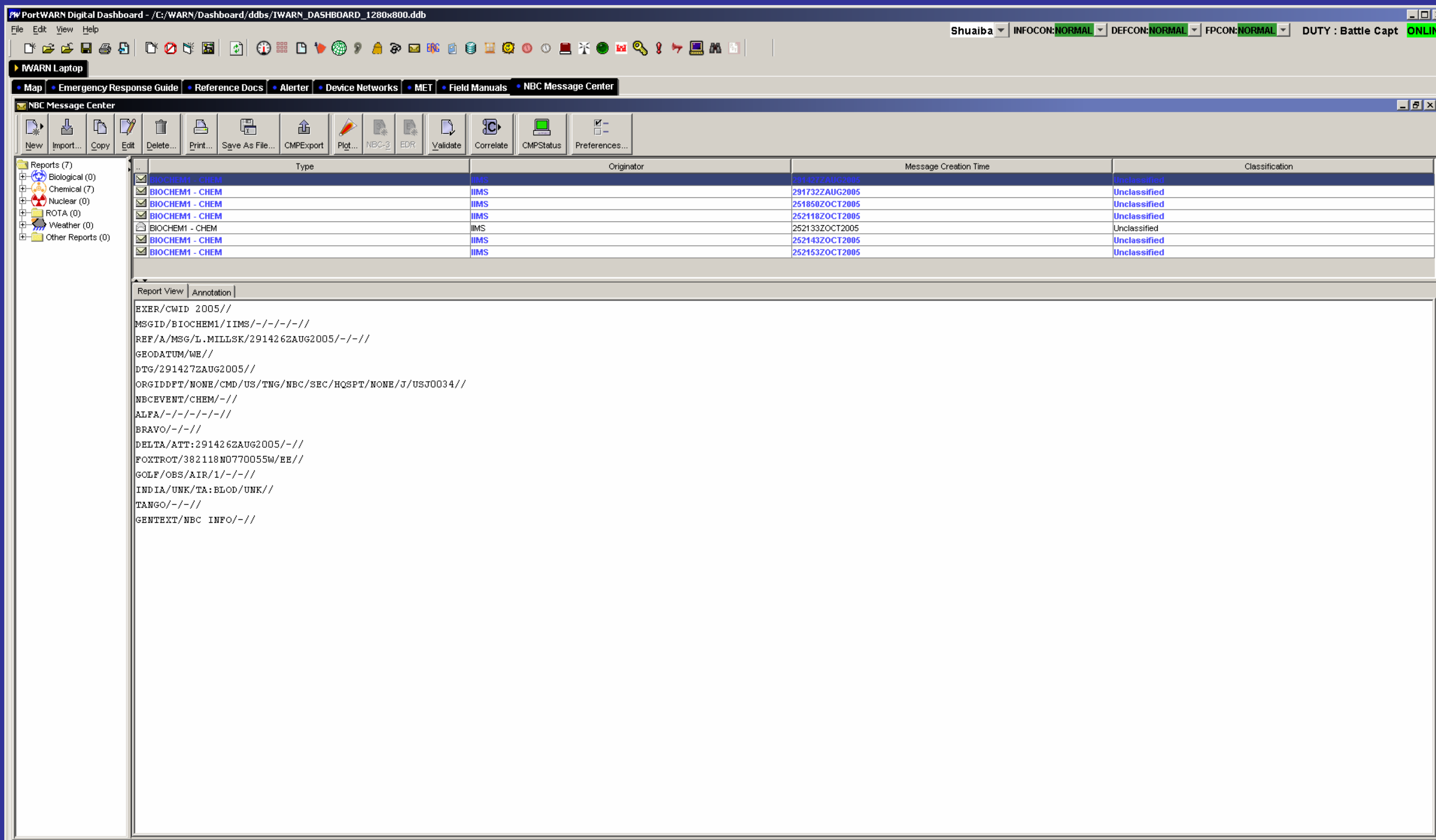
C. Time of Departure

6. What was the departure time of the patrol?
9-Sep-05 04:00

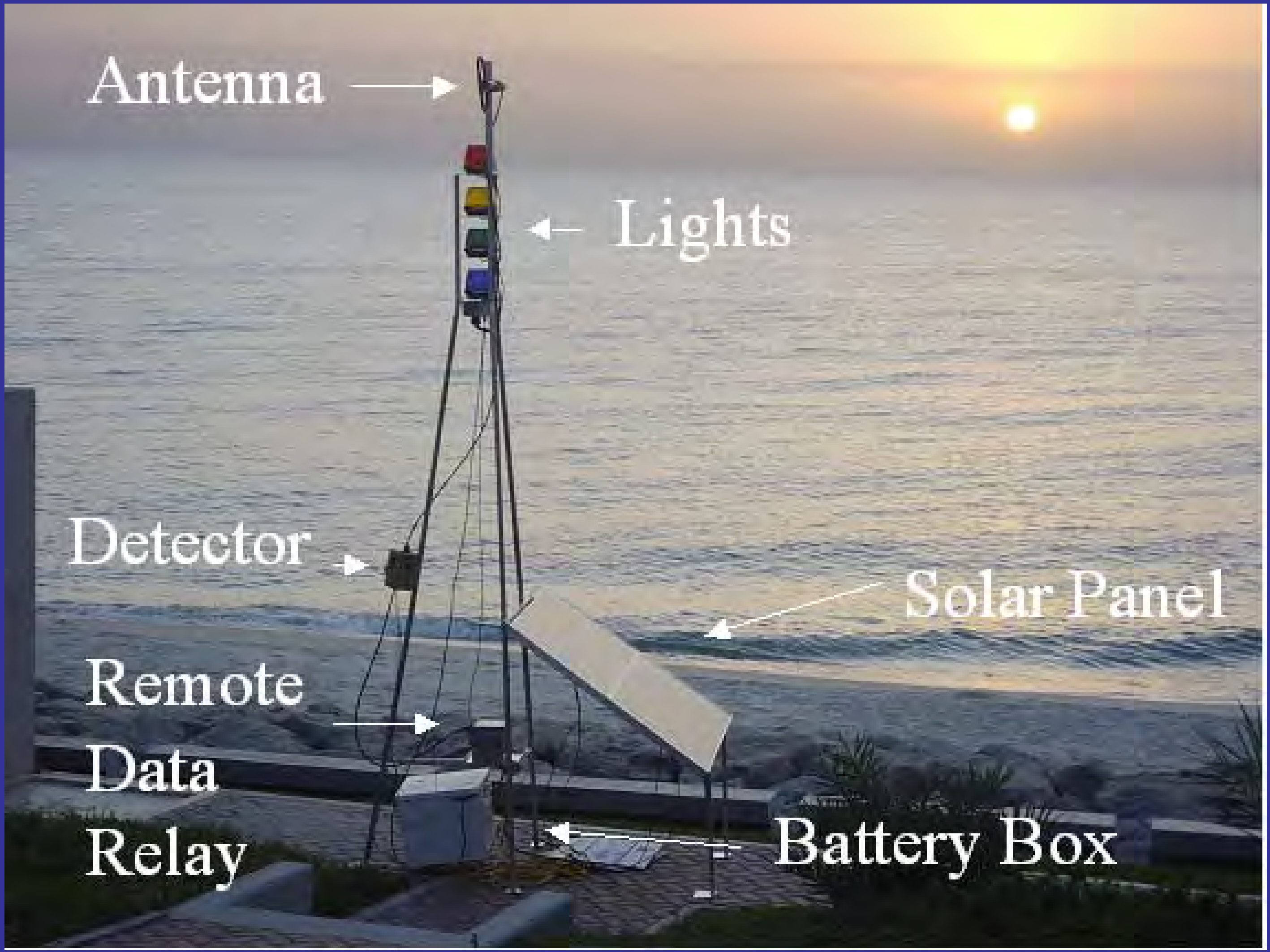
CBRN Detector Networks



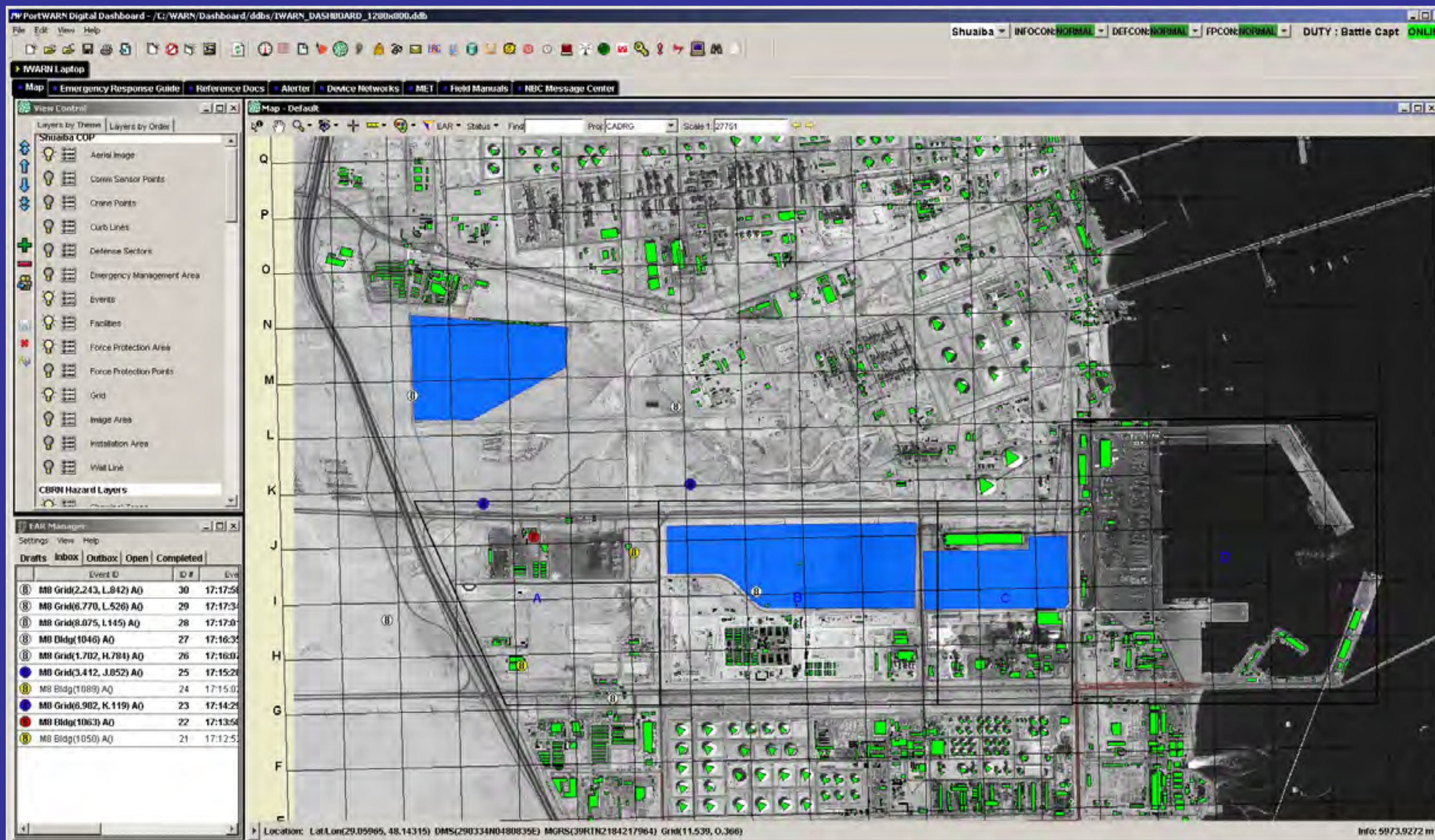
CBRN Messaging



CBRN Warning Networks

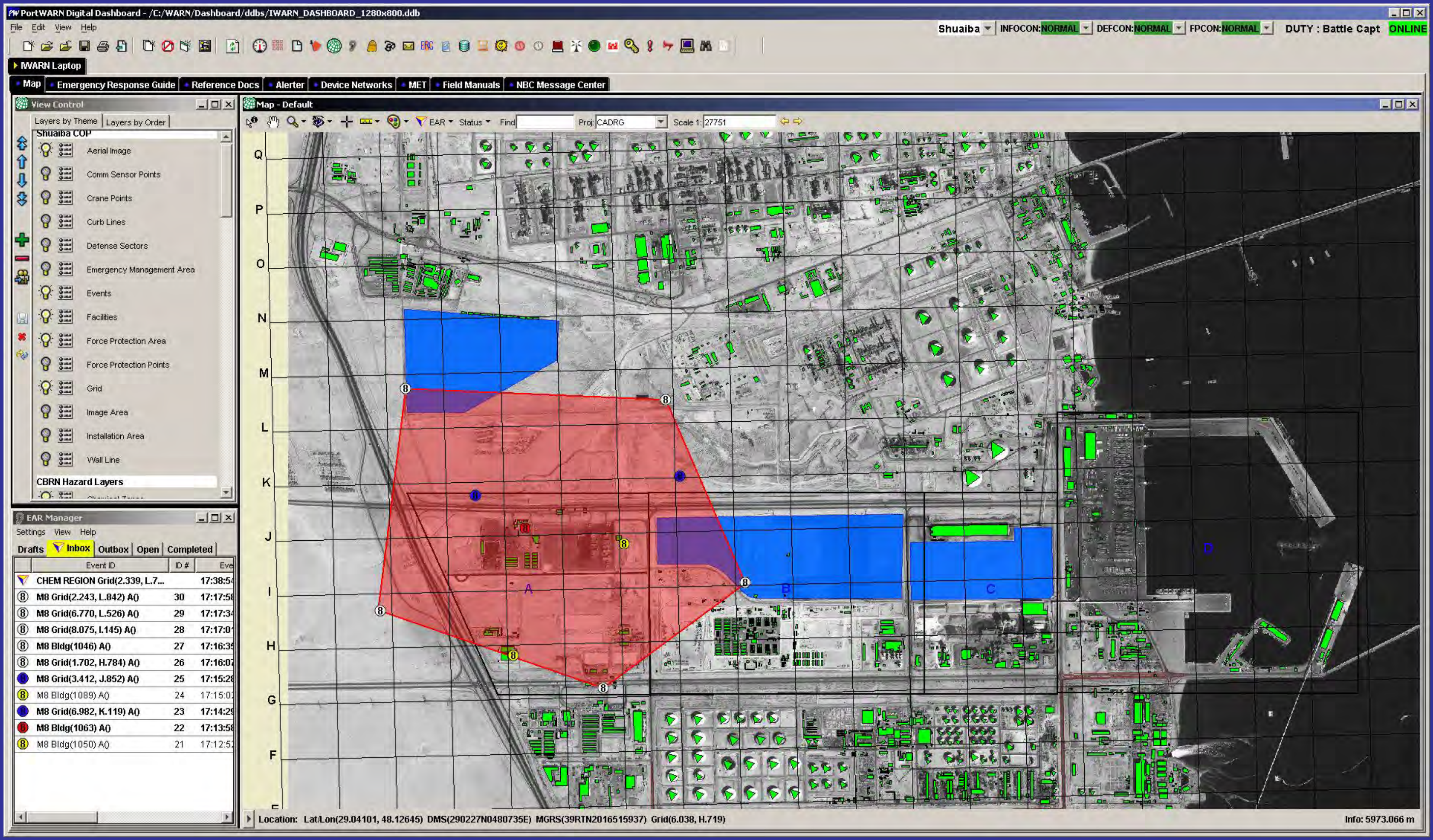


M8 Detection



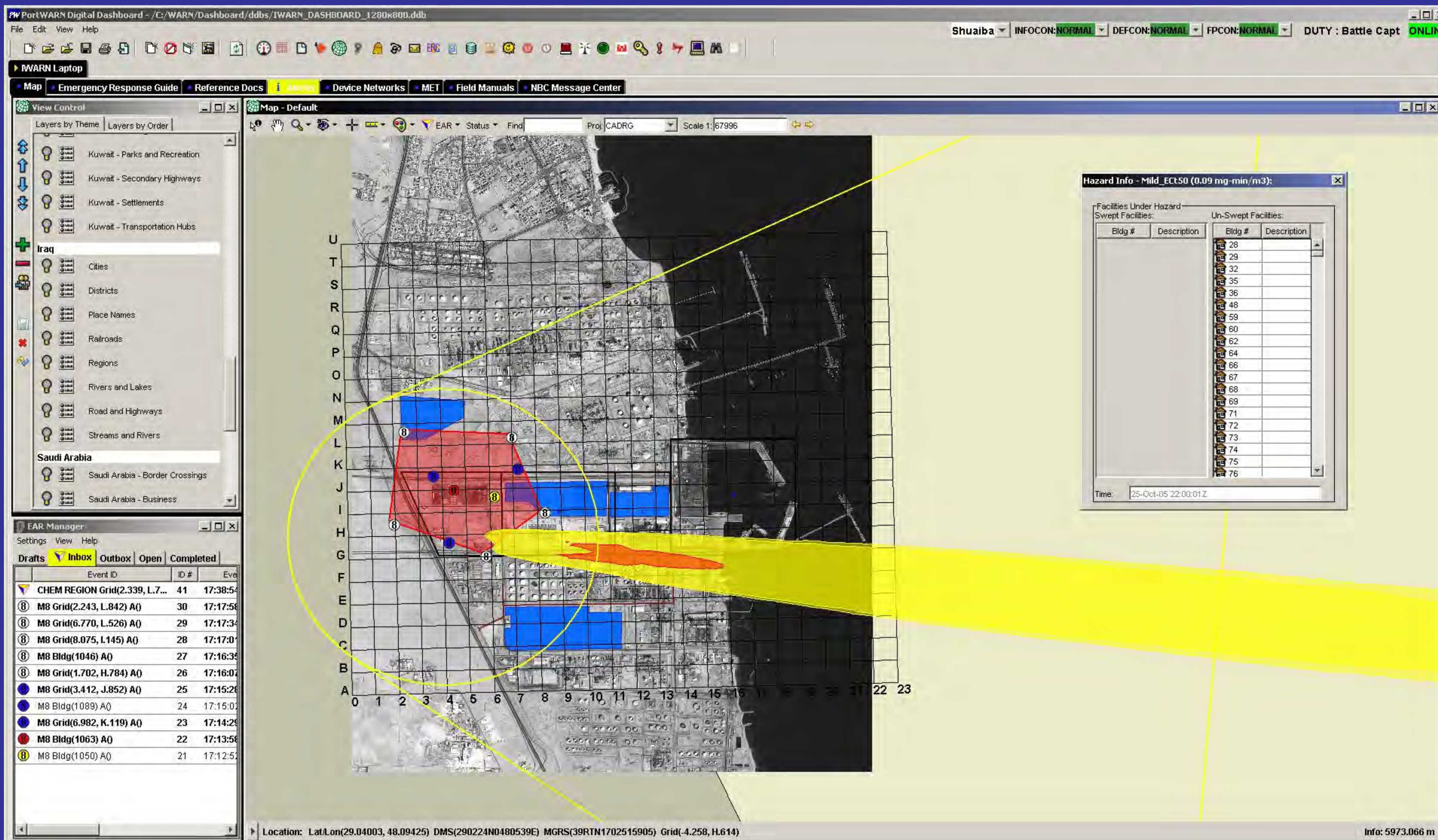
- Detections analyzed and believed to be real
  - SME evaluated the data points

Chem Region Drawn by SME



- SME determines region contaminated at level of detections
  - Manually tag data points to region and resources in it according to SME

Contaminated Region from Model



- Model predicts contamination levels based on detections and formalized SME
  - Automated tagging of data points to region and resources in it

CBRN Message Content Management

CBRN Message Content Management

Full Message

EXER/-//
MSGID/BIOCHEM3/-/-/-/-/-//
GEODATUM/-//
DTG/091750ZJAN2007//
ORGIDDFT/-/-/-/-/-/-/-/-/-//
NBCEVENT/CHEM/-//
ALFA/NAT:US/SAMPLE/001/C/-//
DELTA/ATT:241815ZMAY2004/-//
FOXTROT/395219N0764543W/AA//
GOLF/OBS/AIR/1/BOM/5//
INDIA/SURF/TA:NERV/NP//
PAPAA/1KM/-/50KM/-//
PAPAX/241815ZMAY2004/395148N0764532W/395147N0764539W/395147N0764547W
/395148N0764554W/395150N0764601W/395152N0764607W/395156N0764613W
/395200N0764617W/395205N0764621W/395211N0764624W/395216N0764625W
/395222N0764625W/395227N0764624W/395518N0764524W/395905N0764405W
/395334N0763656W/395234N0764149W//
PAPAX/241900ZMAY2004/402016N0765717W/401422N0761401W/395349N0763638W
/395334N0763656W/395320N0763715W/395257N0763759W/395240N0763847W
/395229N0763938W/395226N0764031W/395229N0764123W/395234N0764149W
/395147N0764539W/395147N0764547W/395150N0764601W/395152N0764607W
/395156N0764613W/395205N0764621W/395211N0764624W/395222N0764625W
/395518N0764524W//
XRAYB/50/RAT:0.3MM3/395215N0764553W/395213N0764549W/395213N0764543W
/395215N0764534W/395215N0764532W/395215N0764531W/395217N0764525W
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/395231N0764556W/395225N0764557W/395219N0764556W//
XRAYB/50/RAT:0.5MM3/395215N0764553W/395214N0764551W/395213N0764547W
/395214N0764540W/395215N0764538W/395215N0764537W/395216N0764533W
/395216N0764530W/395217N0764528W/395220N0764519W/395221N0764516W ……
YANKEE/045DGT/14KPH//
GENTEXT/NBC INFO/-//

Evacuation Message

EXER/-//
MSGID/BIOCHEM3/-/-/-/-/-//
GEODATUM/-//
DTG/091750ZJAN2007//
ORGIDDFT/-/-/-/-/-/-/-/-/-//
NBCEVENT/CHEM/-//
ALFA/NAT:US/SAMPLE/001/C/-//
DELTA/ATT:241815ZMAY2004/-//
FOXTROT/395219N0764543W/AA//
GOLF/-/-/-/-/-//
INDIA/UNK/-/-//
PAPAA/1KM/-/50KM/-//
PAPAX/241815ZMAY2004/395148N0764532W/395147N0764539W/395147N0764547W
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/395334N0763656W/395320N0763715W/395257N0763759W/395240N0763847W
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XRAYB/-/-/395215N0764553W/395213N0764549W/395213N0764543W
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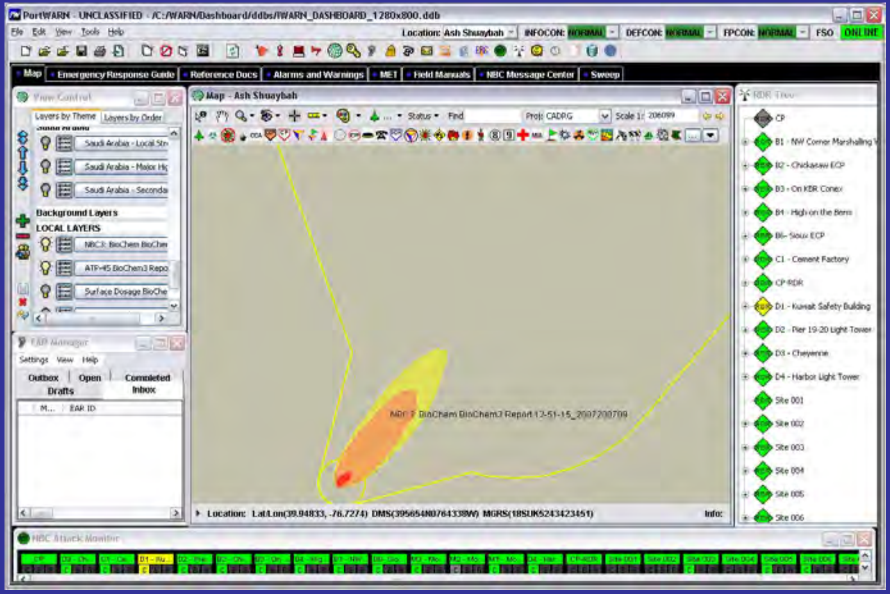
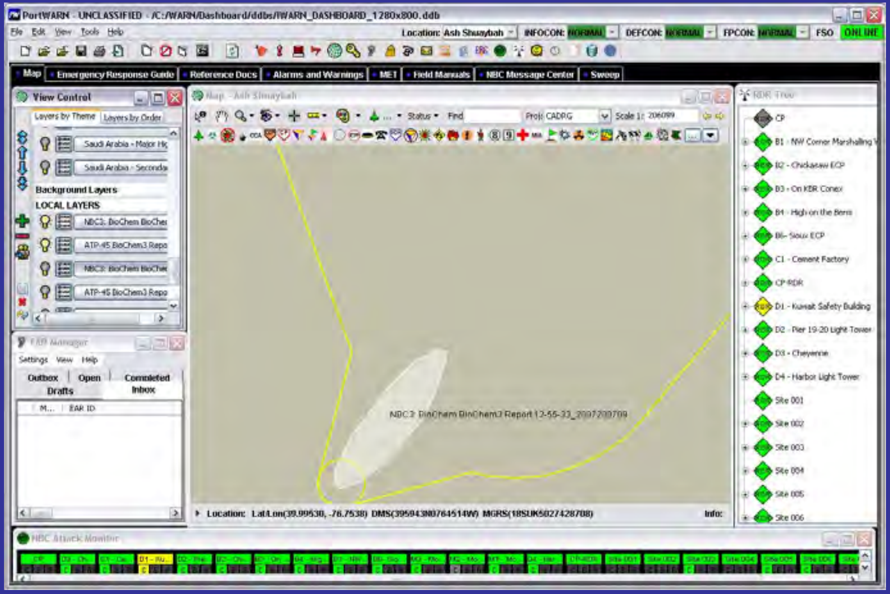
/395252N0764547W/395244N0764552W/395242N0764552W/395237N0764555W
/395231N0764556W/395225N0764557W/395219N0764556W//
YANKEE/045DGT/14KPH//
GENTEXT/NBC INFO/
This Report was generated by the Evacuation Report Tool//

CBRN Message Content Management

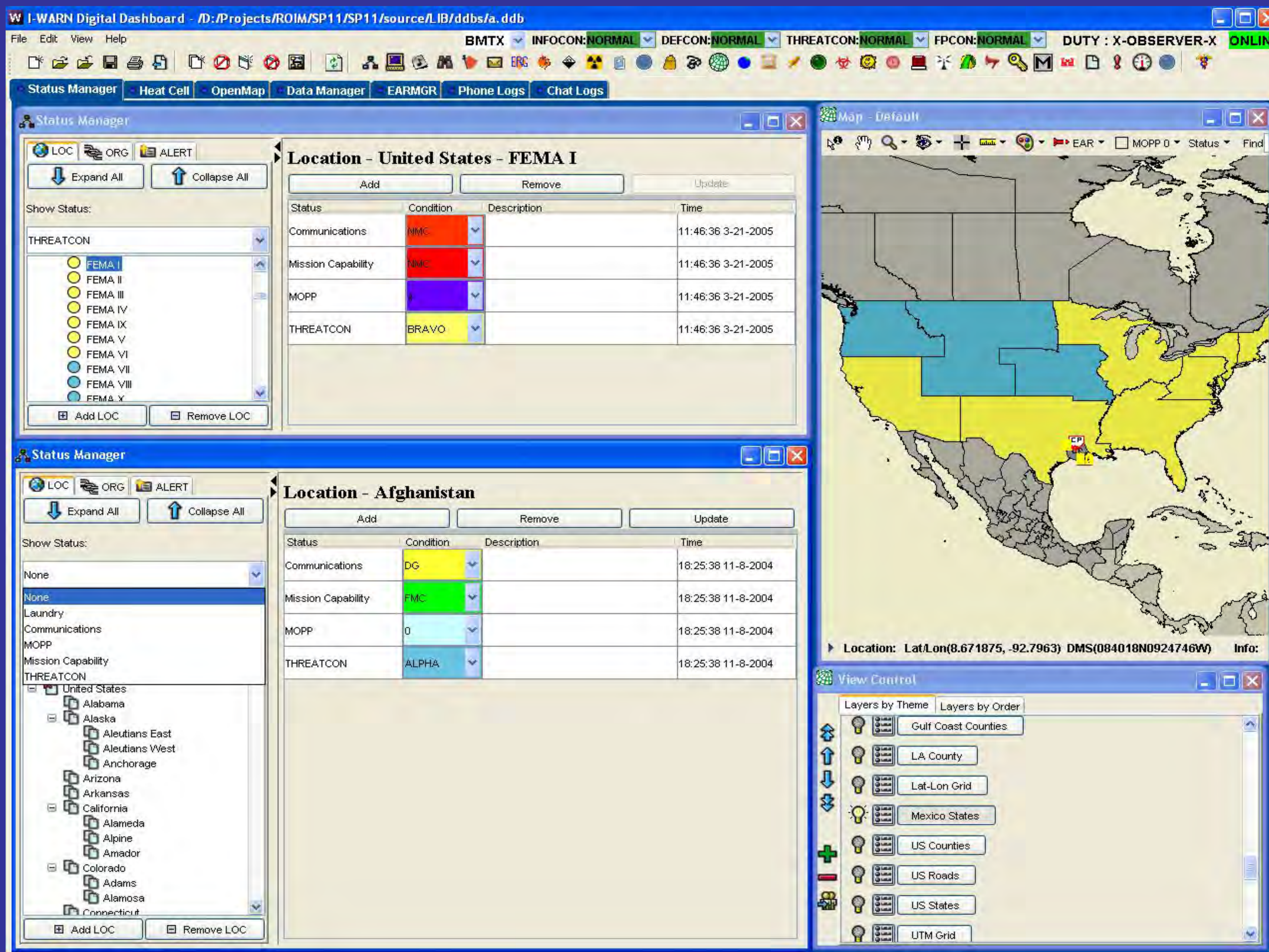
Full Message



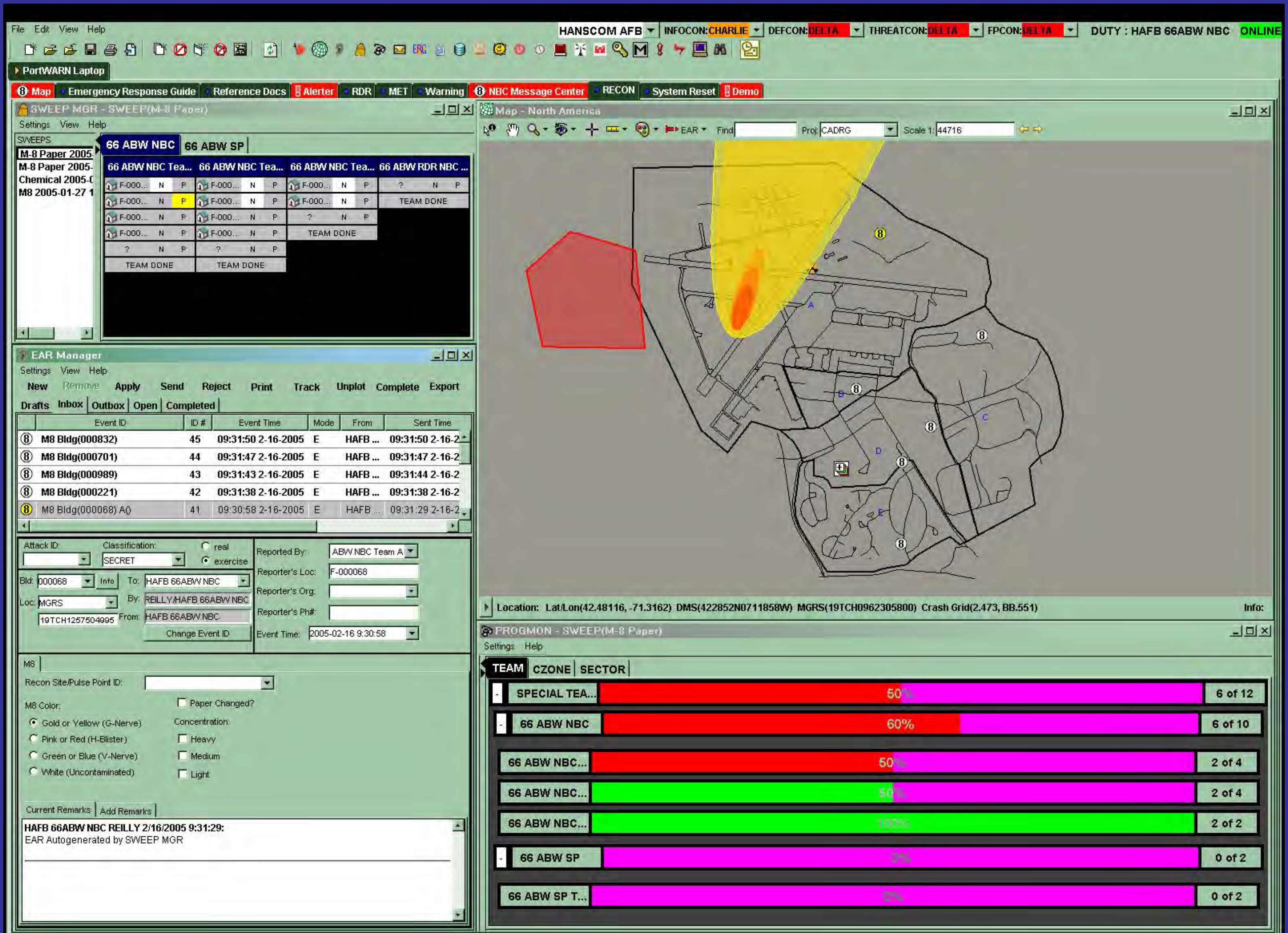
Evacuation Message



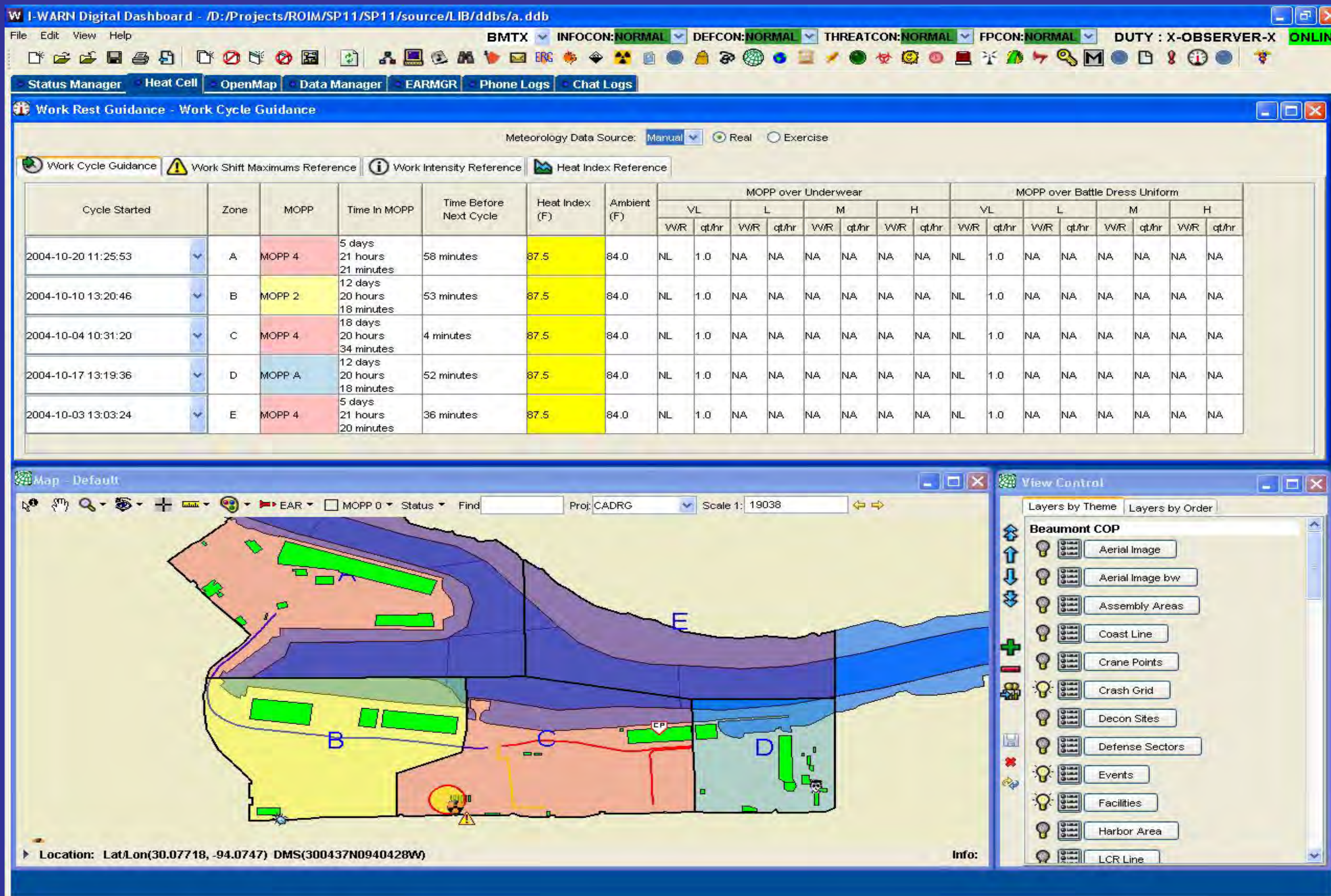
Status Summary and CON Toolbar



Sweep Manager and Progress Monitor

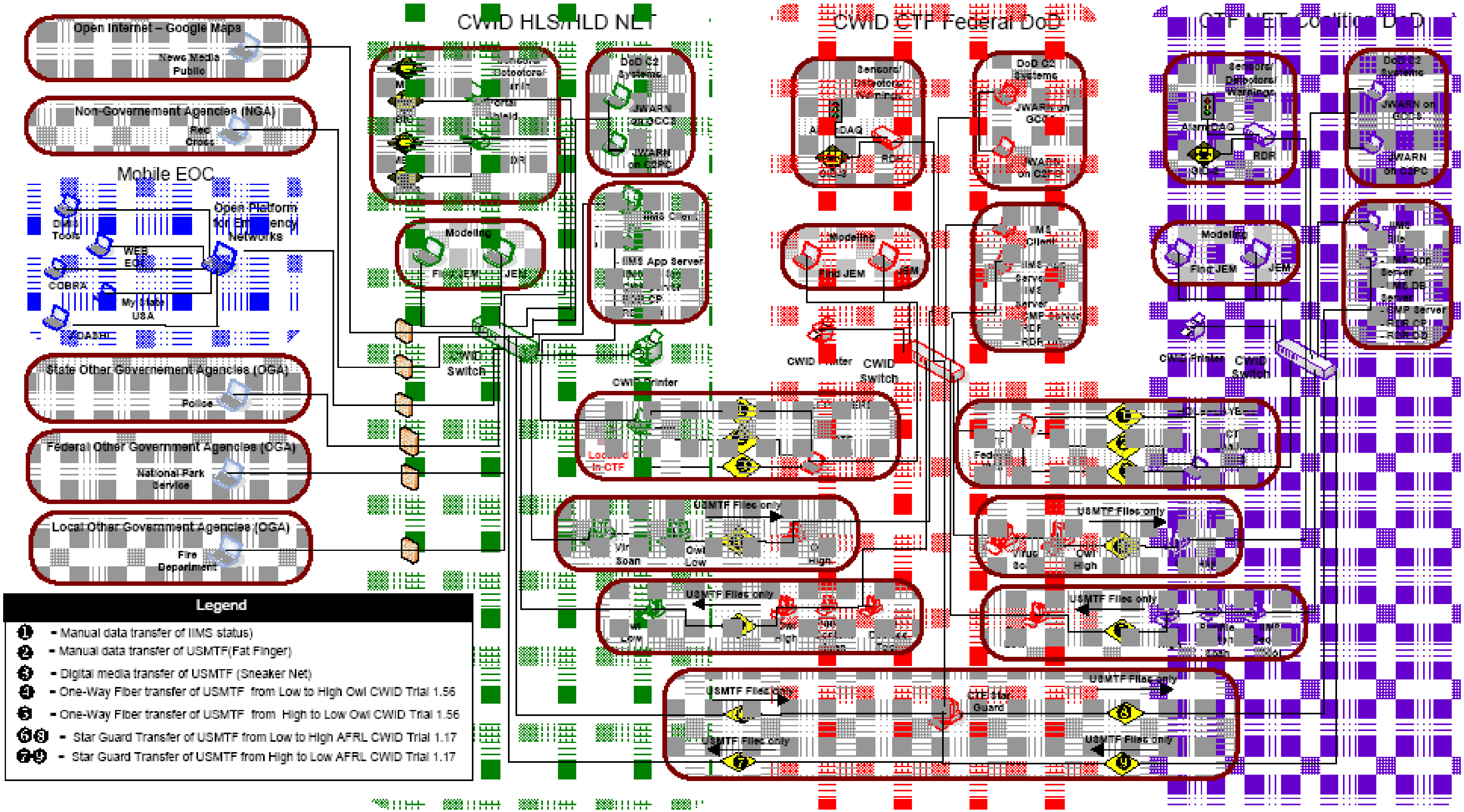


Heat Index Guidance



Cycle Started	Zone	MOPP	Time In MOPP	Time Before Next Cycle	Heat Index (F)	Ambient (F)	MOPP over Underwear								MOPP over Battle Dress Uniform							
							VL		L		M		H		VL		L		M		H	
							W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr	W/R	qt/hr
2004-10-20 11:25:53	A	MOPP 4	5 days 21 hours 21 minutes	58 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA
2004-10-10 13:20:46	B	MOPP 2	12 days 20 hours 18 minutes	53 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA
2004-10-04 10:31:20	C	MOPP 4	18 days 20 hours 34 minutes	4 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA
2004-10-17 13:19:36	D	MOPP A	12 days 20 hours 18 minutes	52 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA
2004-10-03 13:03:24	E	MOPP 4	5 days 21 hours 20 minutes	36 minutes	87.5	84.0	NL	1.0	NA	NA	NA	NA	NA	NA	NL	1.0	NA	NA	NA	NA	NA	NA

Battle Management Data Flow Diagram



Implementation of the CBRN Data Model

CBRN Data Model

- Evaluated
  - CBRN Messages
  - Detector and Sensor Data
    - In process

- Database Normalization
  - CBRN Report is a hierarchy of groups broken down into fields
  - Table relationships in the data model do not mirror the relationships in the reporting standard
  - Each group in the message maps to multiple tables in the model
  - Each table in the model may handle data from more than one group

CBRN Data Model Recommendation

- It works
- No show stoppers, but too comprehensive for specialized uses

- Use the same data structure at multiple levels
  - Remote Data Relay comm node
  - Remote Data Relay Command Post
  - IIMS Database

- Build lightweight sub schemas for specialized uses
  - CBRN messages
  - Sensor and detector data

Battle Management Requirement for Effective use of Models

- Keep models one layer deep
- Replace predicted results with ground truth or known results at every level

It’s not done

- Improved data acquisition and distribution
  - Field observation data
  - Sensor / detector / warning networks
  - Other C2 systems
- Easier integration of analytical models and SME analysis
  - Impact region
  - Operational effects
  - Human effects
  - Confidence
- Easier insertion of response plan and real time response
  - Checklists, sweeps, BSD
  - EAR grouping and information tagging
- GUI to effectively and accurately convey knowledge to the warfighter
- Interoperable Information

Computational Chemistry: Example Applications of a Critically Important Tool in Threat Agent Science

11 January 2007

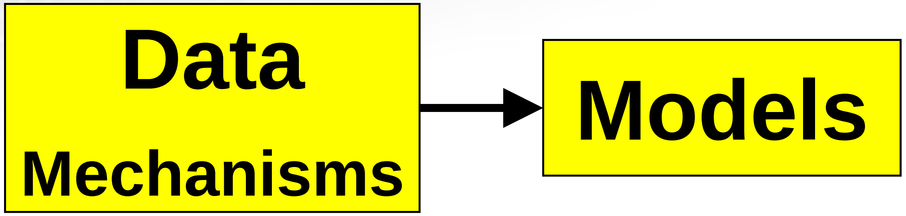
Keith Runge[1], Steve Bunte[2], Douglas Burns[3], Marshall Cory[3], Margaret Hurley[2], DeCarlos Taylor[2], and Joe Vasey[3]

[1]BWD Associates, LLC [2]Army Research Lab [3]ENSCO, Inc

Outline

- Relationship of Theory and Experiment
- Computational Chemistry Applications
  - Atmospheric Chemistry
  - High Temperature Chemistry
  - Surface Chemistry
  - Physical Property Data

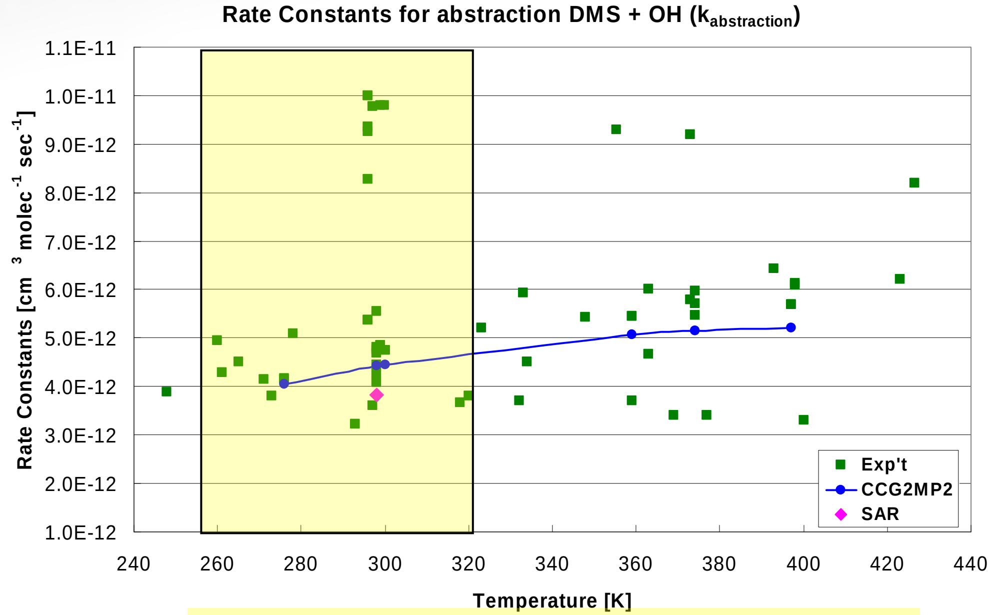
Systems Approach



- Any Compound
- CWAs and Simulants
  - Organophosphorus
  - Sulfur and halogenated
- Toxic Industrial Compounds (TICs)
- Ozone Producing Pollutants

Cooperative Experiment and Theory

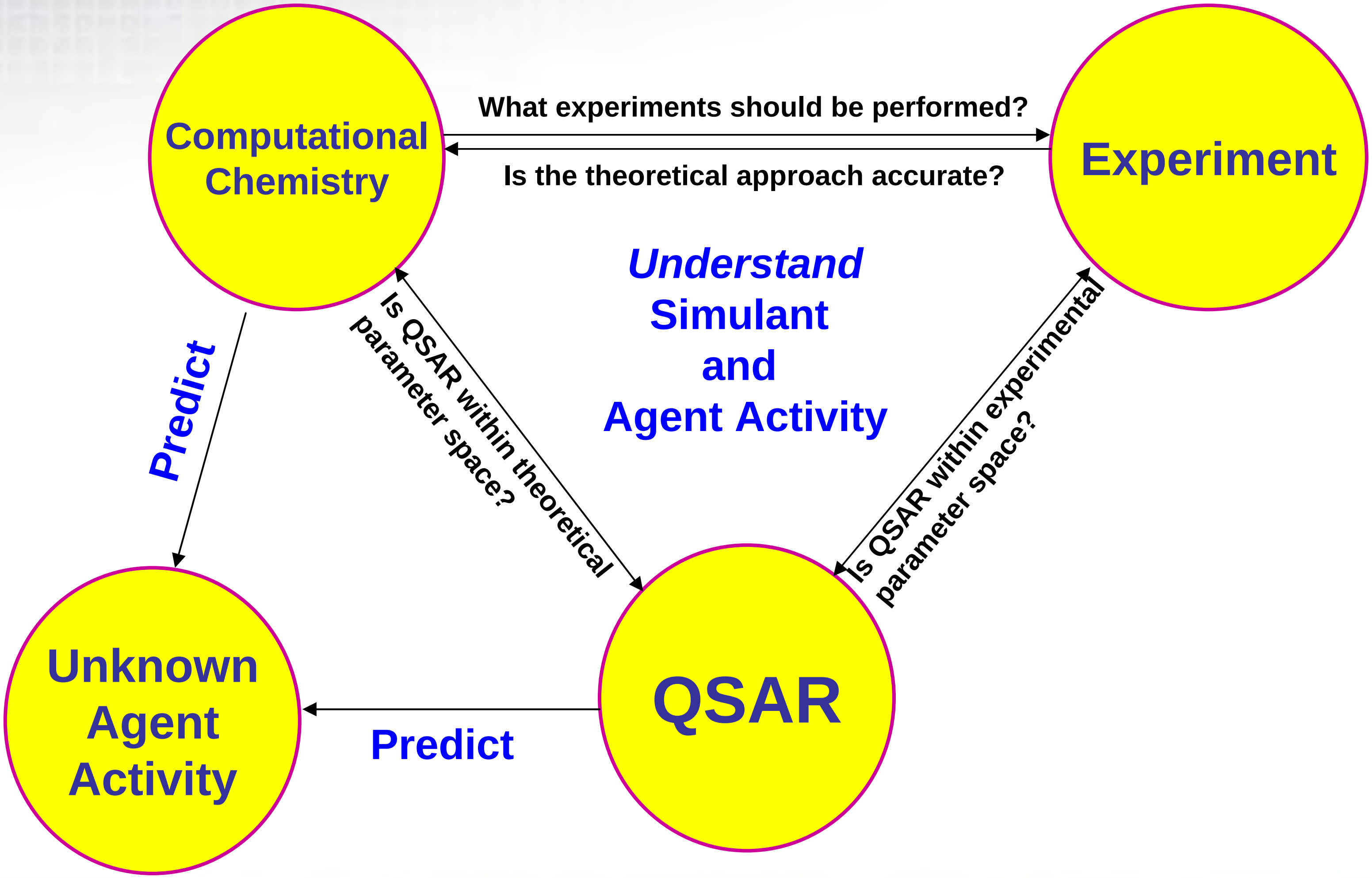
- "Everybody believes the measurement data except the one that made the measurement"
- "Nobody believes the prediction except the one that made the prediction."
- *Trust, but verify*



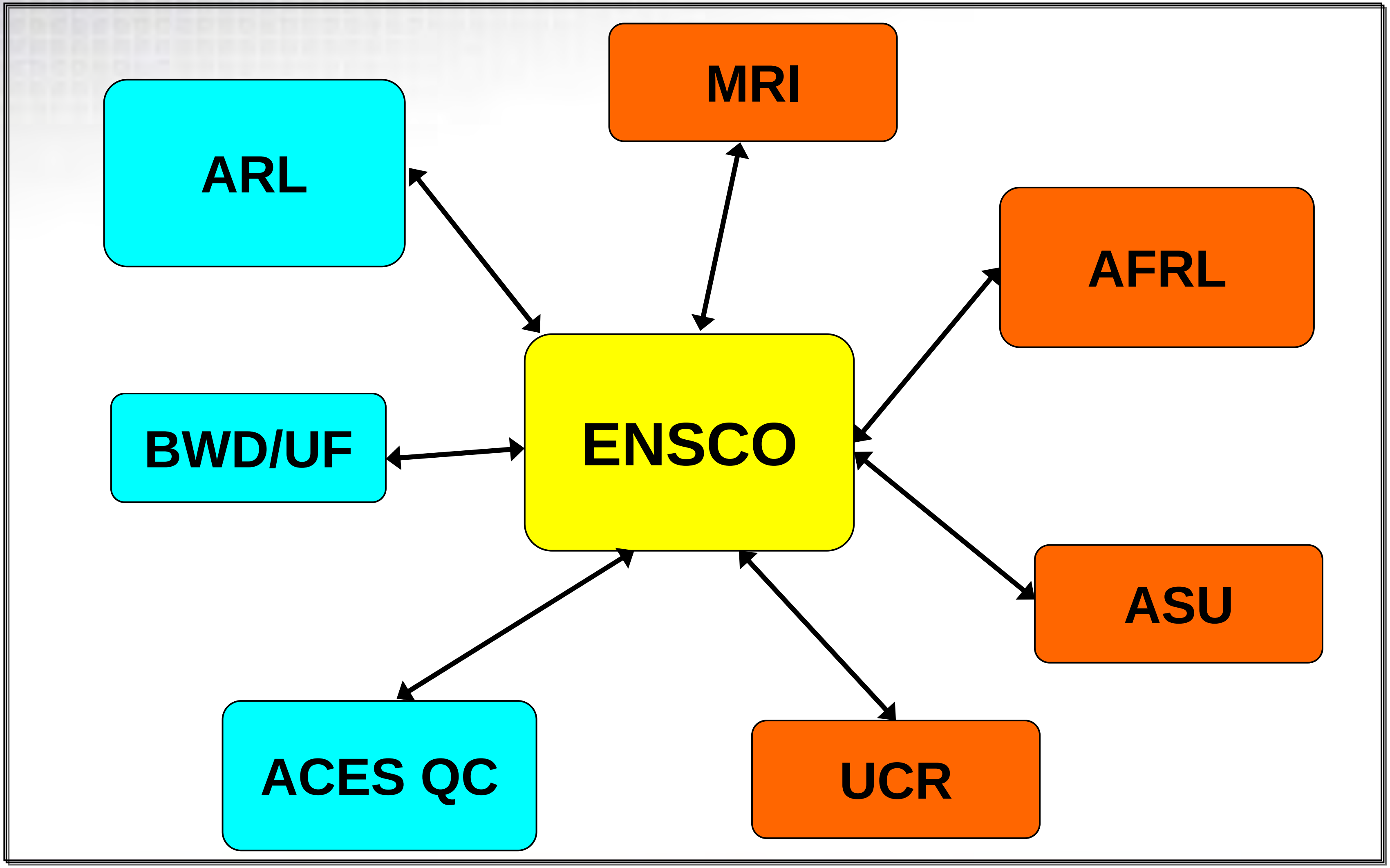
Temperature range of interest to Atmospheric Chemistry

We are able to take only a few measurements and extrapolate to a more complete picture or understanding

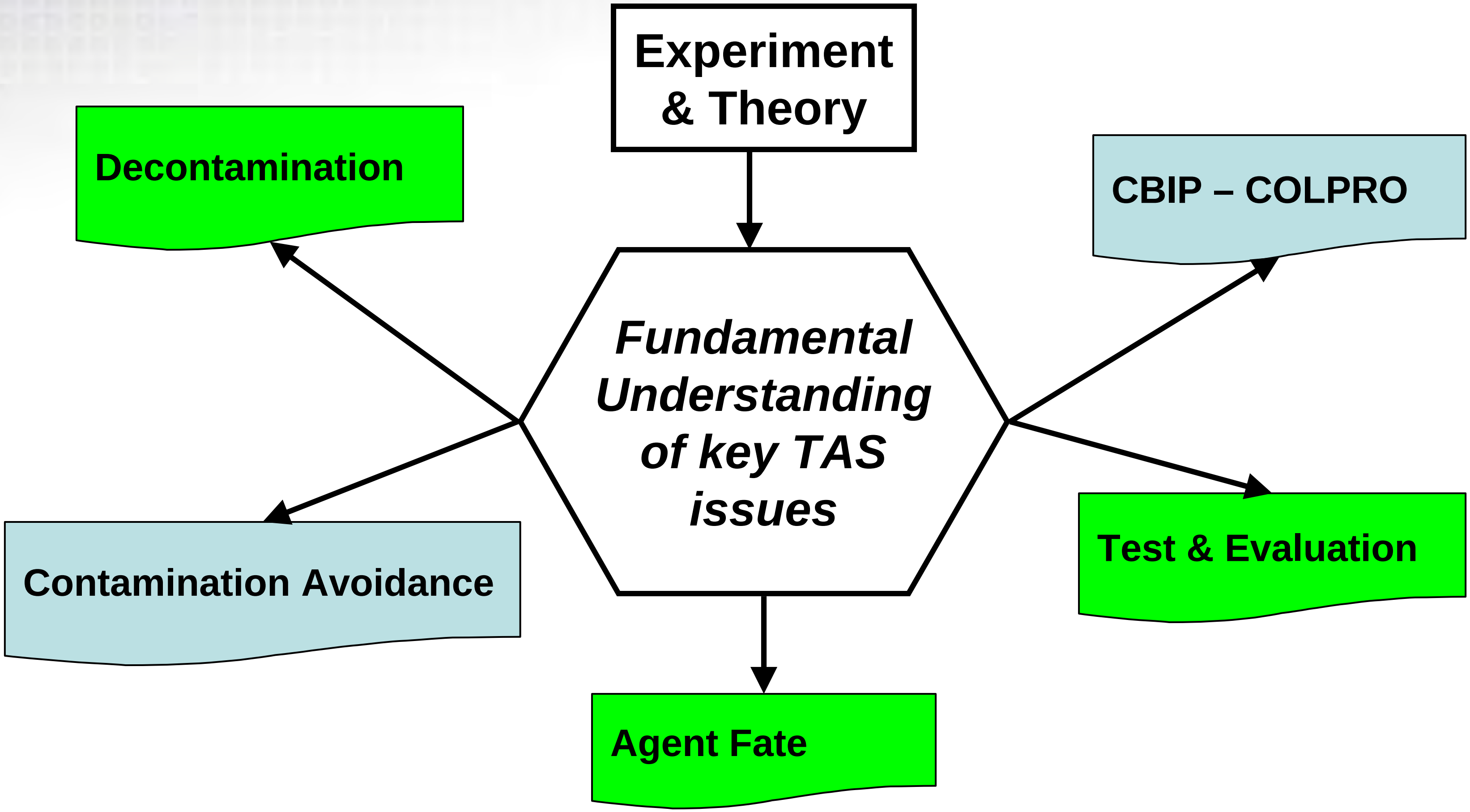
Development of a Mapping Function



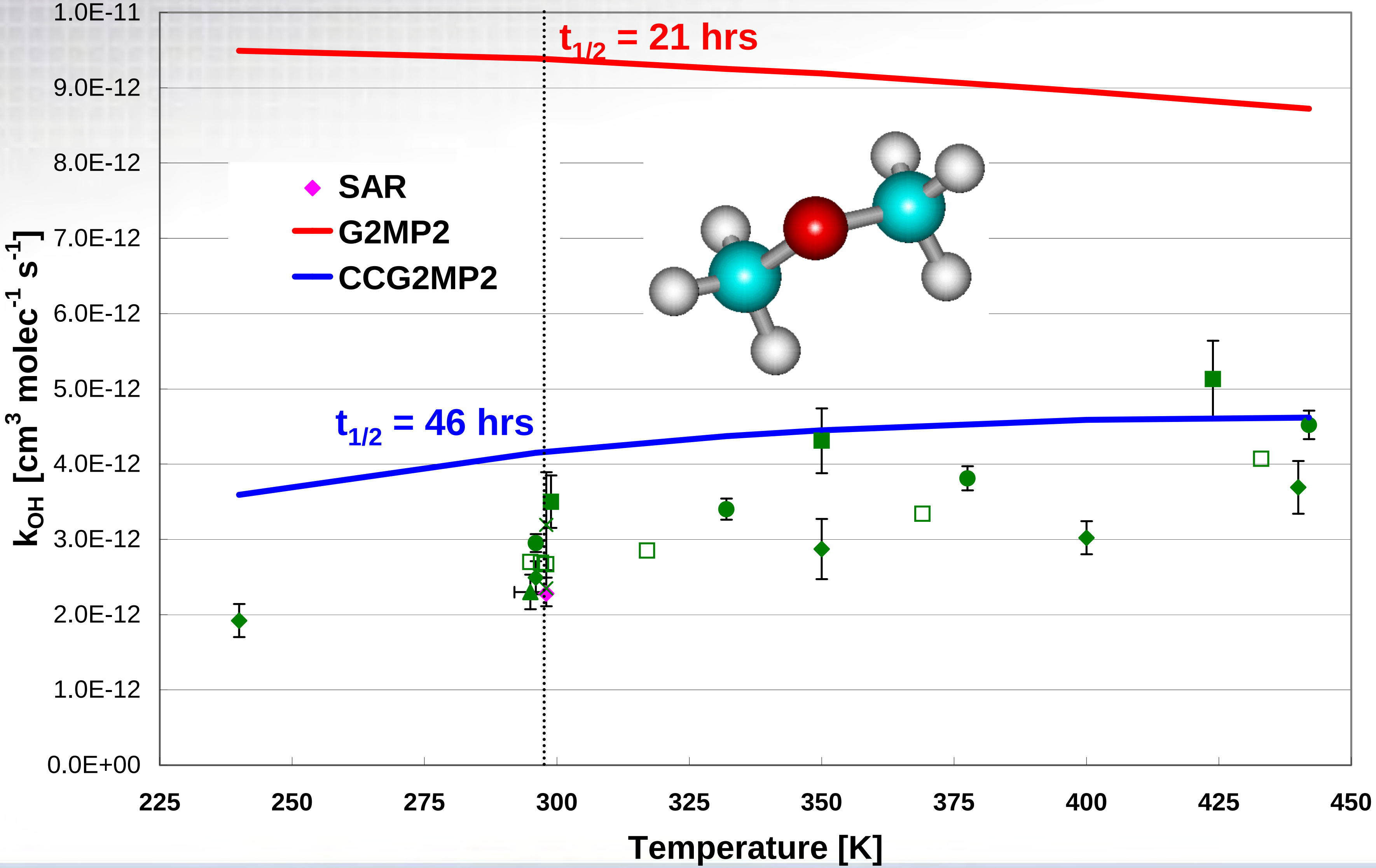
Partner Agencies

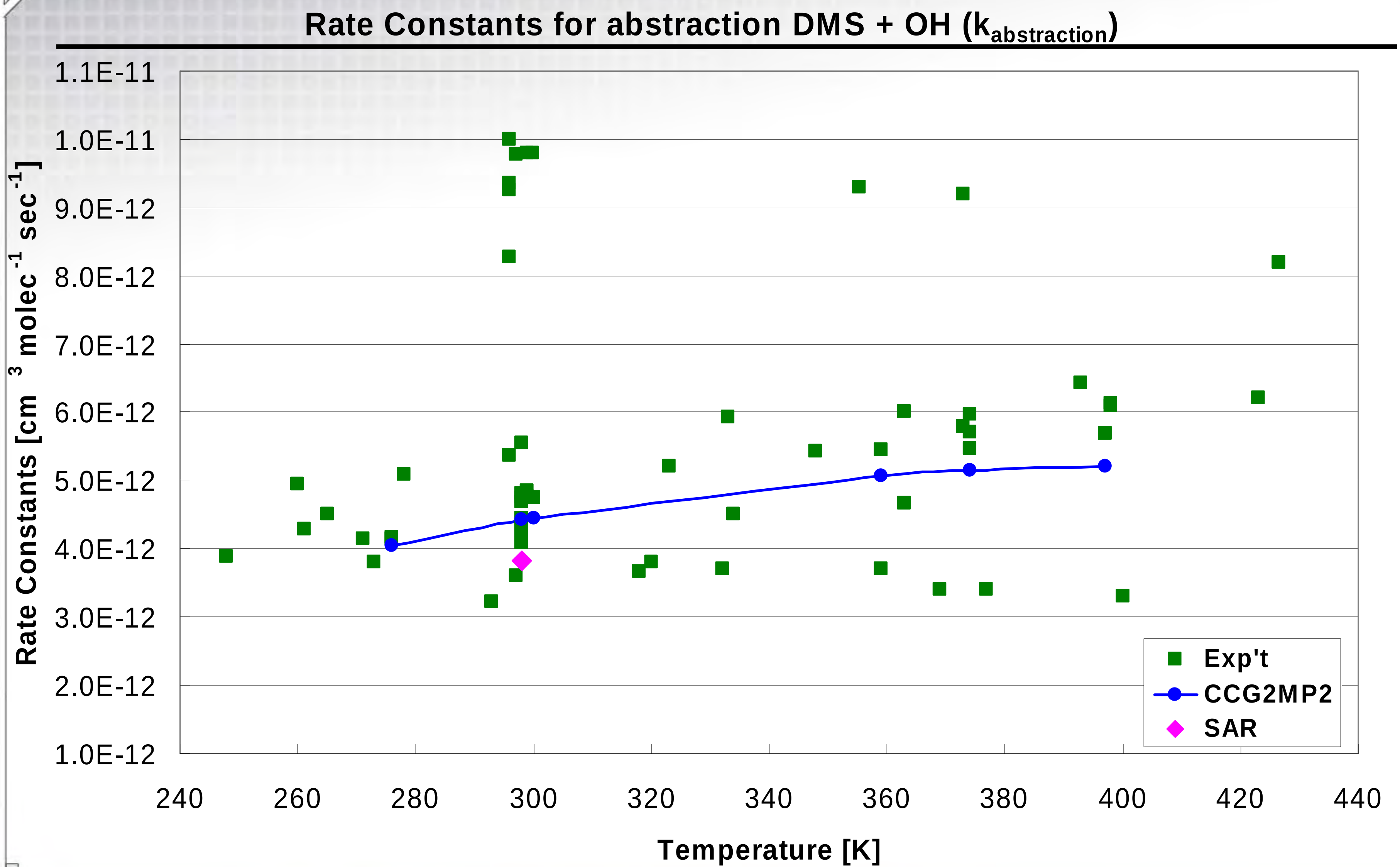


Computational Chemistry
Atmospheric Chemistry



Computational Chemistry: Method Development (DME)



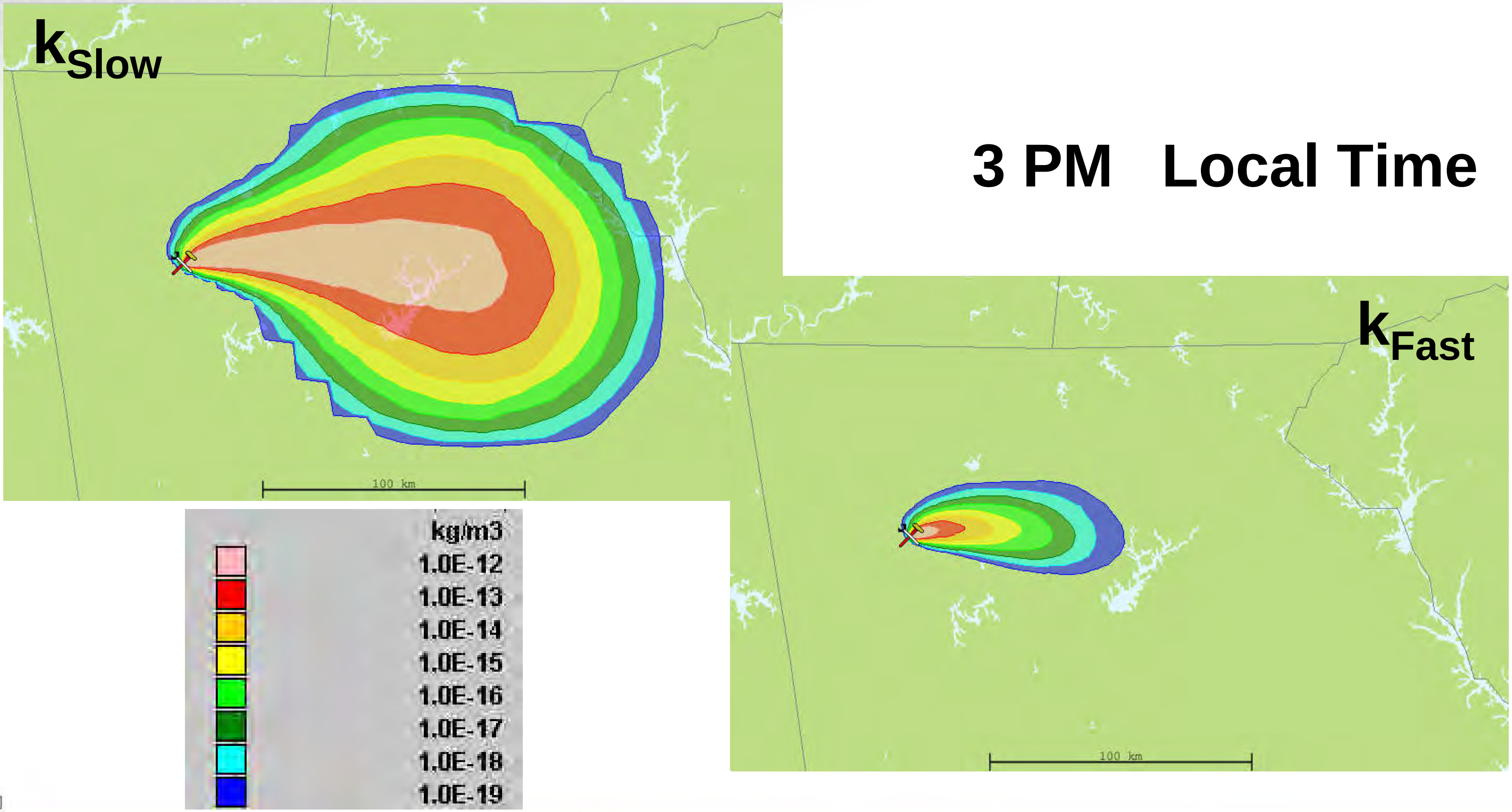


Rate Constants for abstraction DMS + OH ($k_{abstraction}$)
1.1E-11
1.0E-11
9.0E-12
8.0E-12
7.0E-12
6.0E-12
5.0E-12
4.0E-12
3.0E-12
2.0E-12
1.0E-12
Rate Constants [cm^3 $molec^{-1}$ sec^{-1}]
240
260
280
300
320
340
360
380
400
420
440
Temperature [K]
Exp't
CCG2MP2
SAR

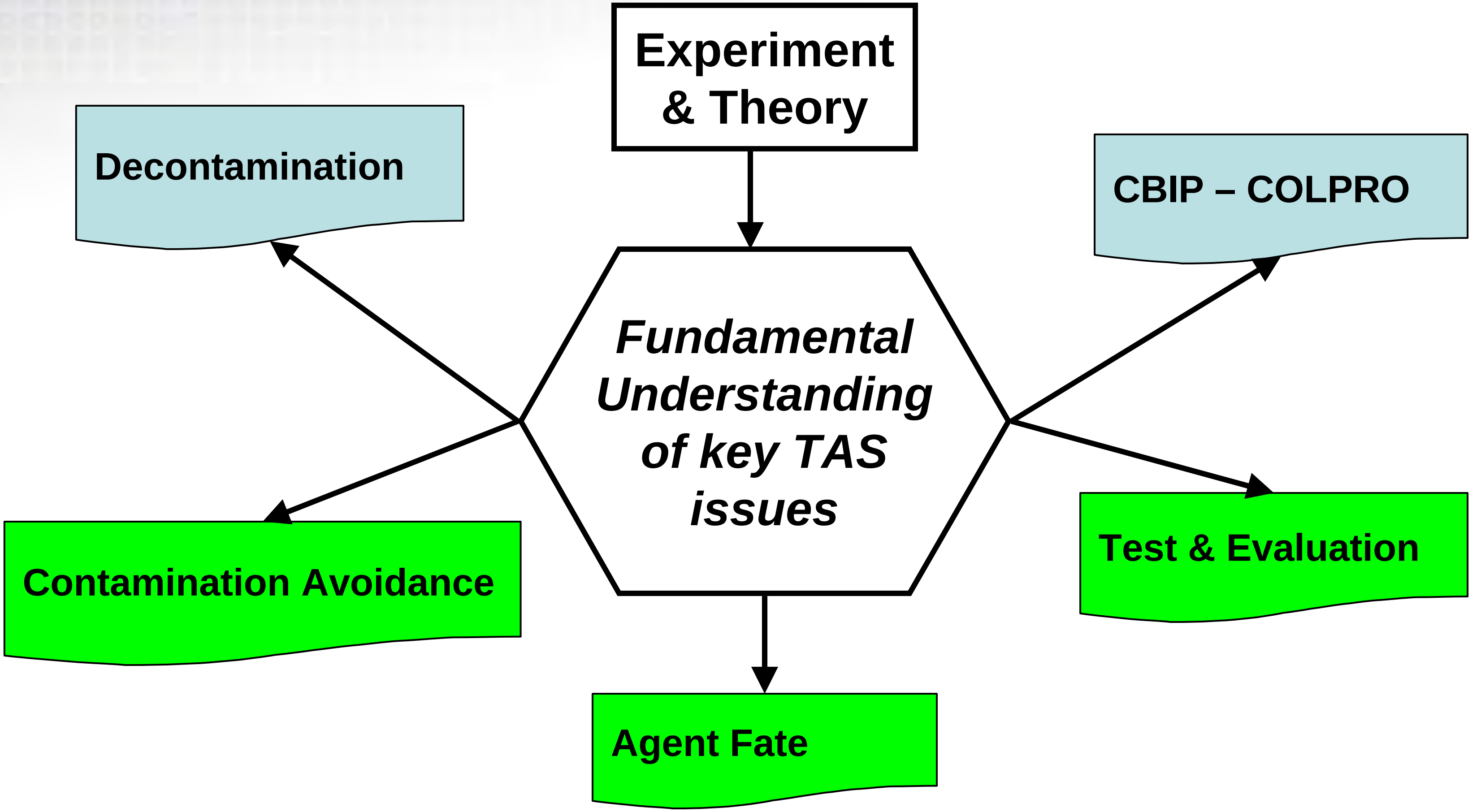
Results: Effect of k_{rxn} on Predicted Footprint

8 hr continuous release starting at 8 am local time

3 PM Local Time

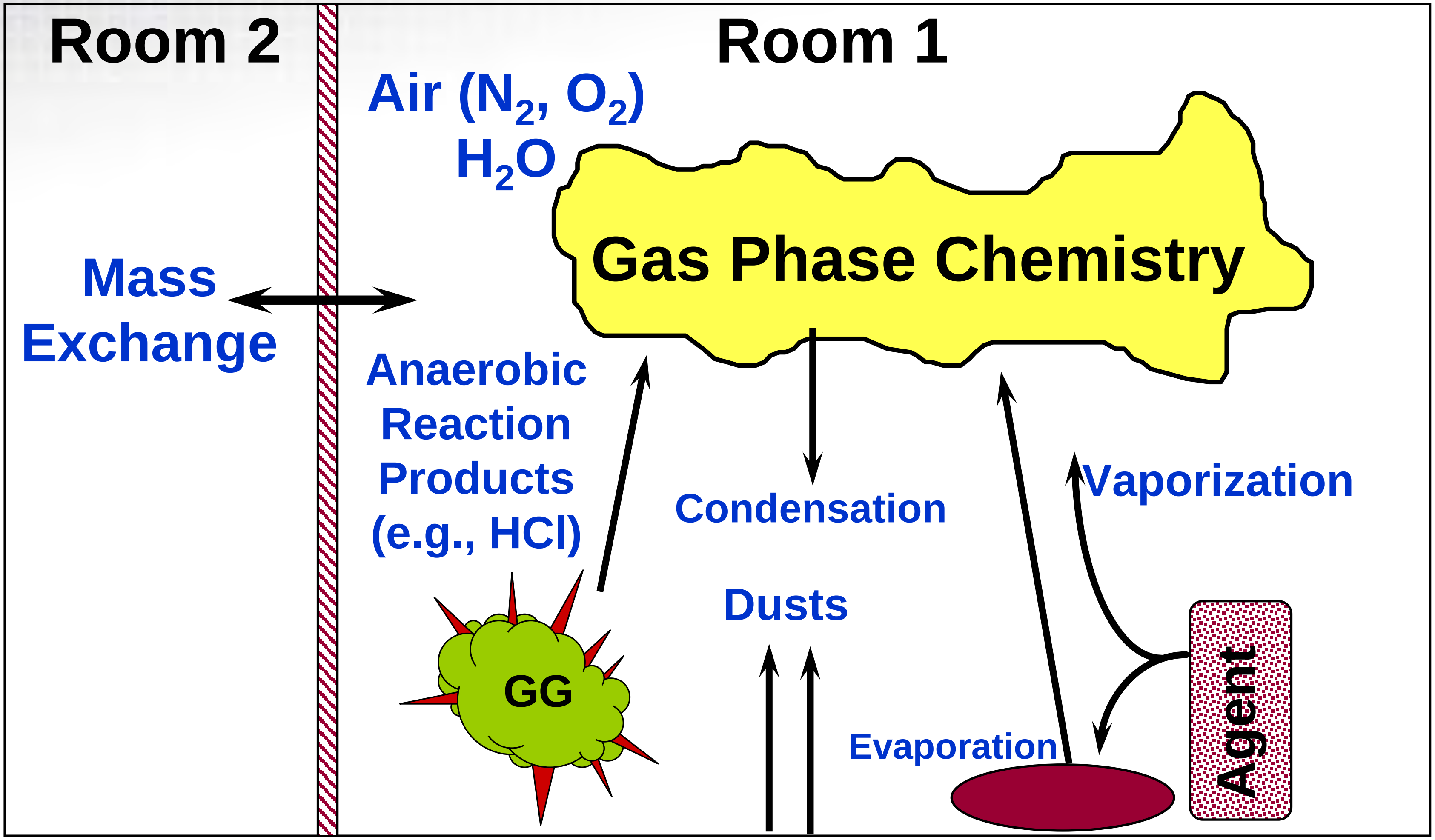


Computational Chemistry
High Temperature Chemistry



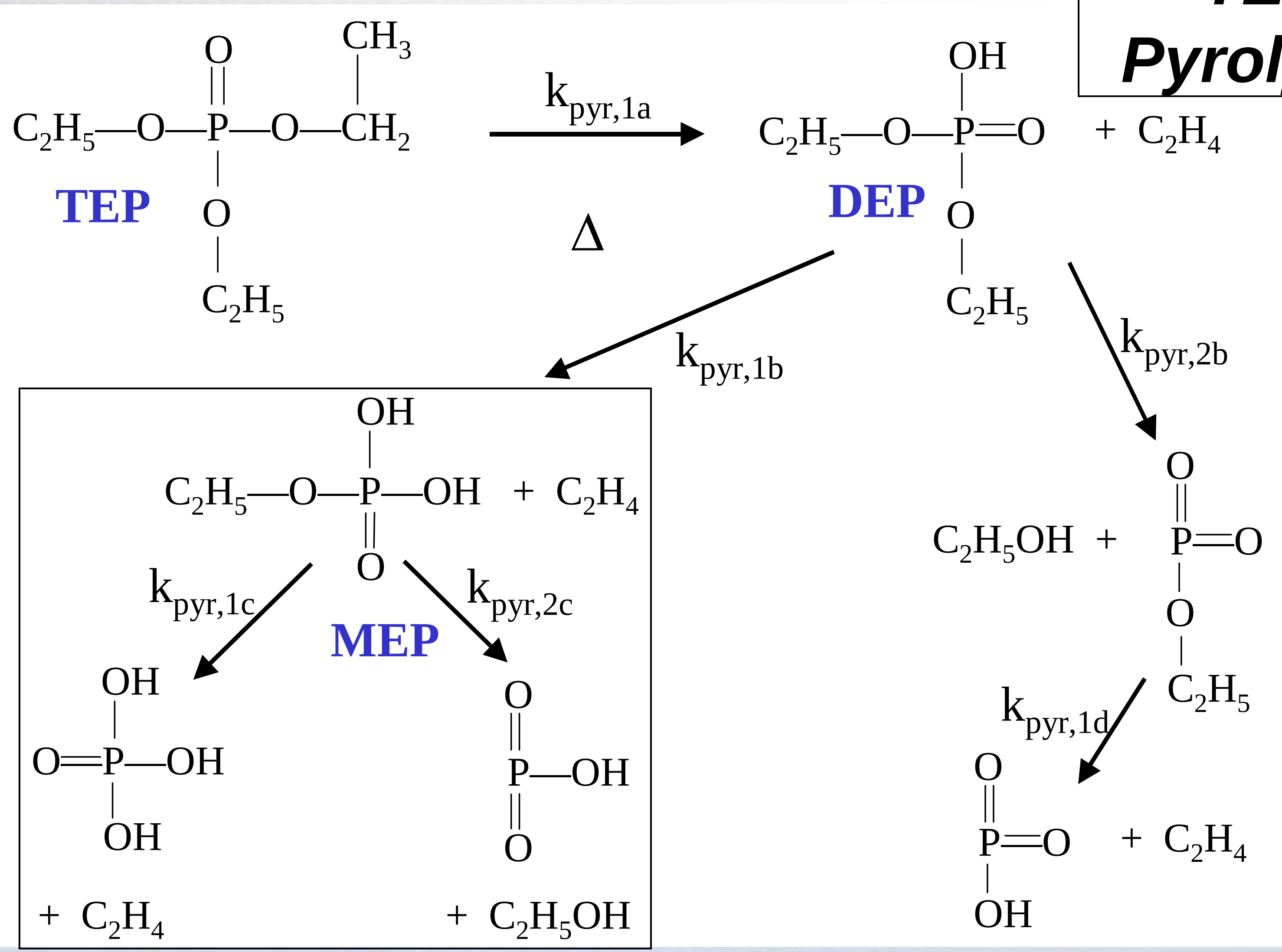
Source Terms: MBLM (Integrate Chemistry)

WMD Collateral Effects Modeling



Source Terms: MBLM (Develop Input Data)

TEP Pyrolysis

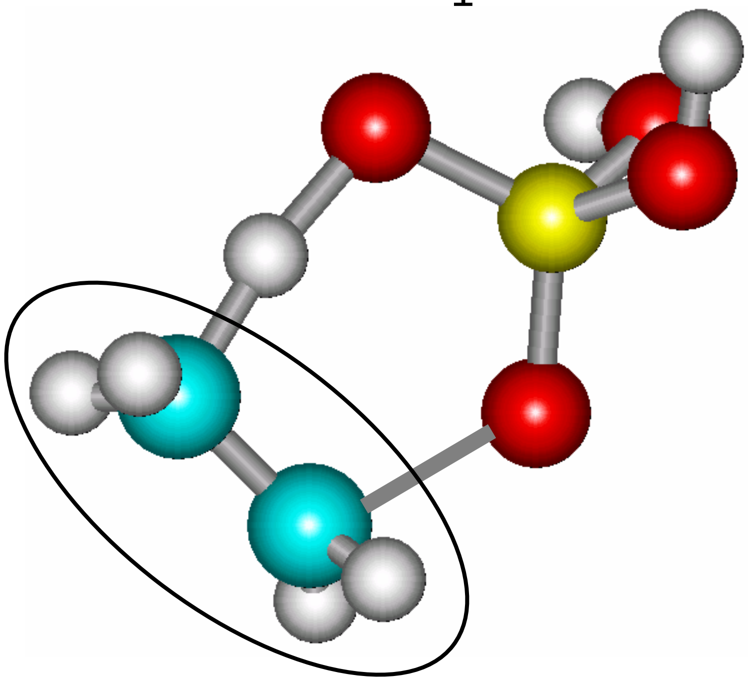


Source Terms: MBLM (Develop Input Data)

TEP Pyrolysis

MEP → $H_3PO_4 + CH_2{=}CH_2$

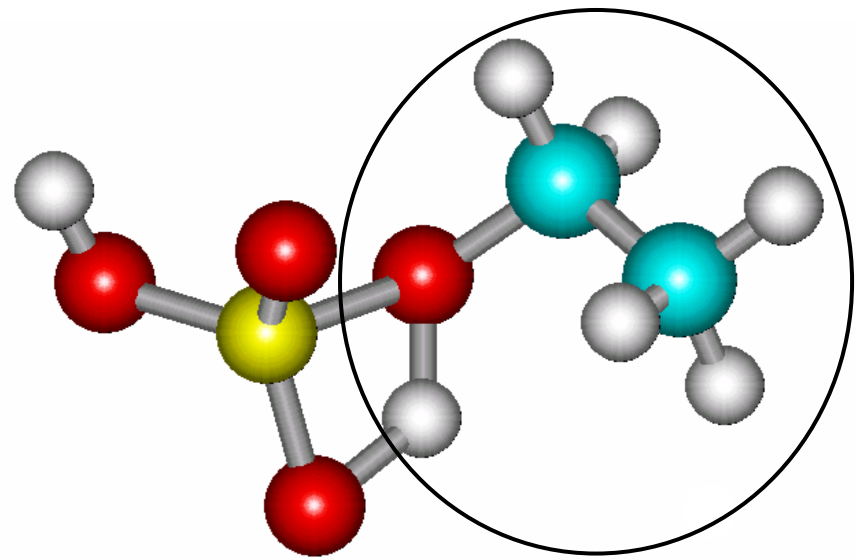
TS_1



$E_A = 41.9$ kcal/mol

MEP → $HPO_3 + CH_3CH_2OH$

TS_2

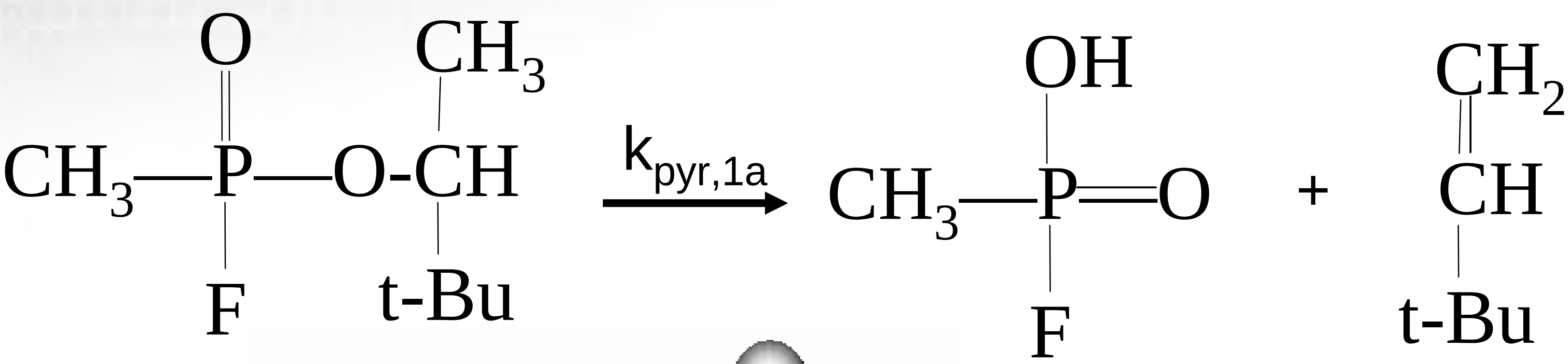


$E_A = 38.9$ kcal/mol

$$k = A_0(T)\exp(-E_A / RT)$$

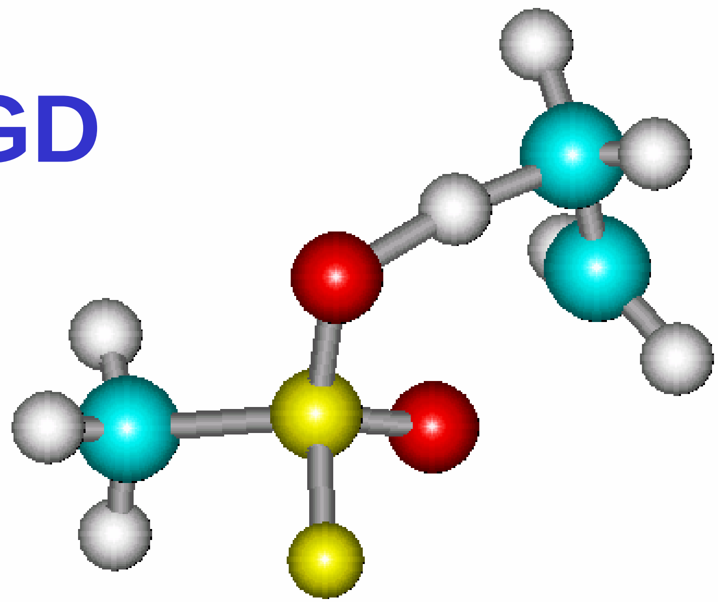
Source Terms: MBLM (Develop Input Data)

GD Pyrolysis

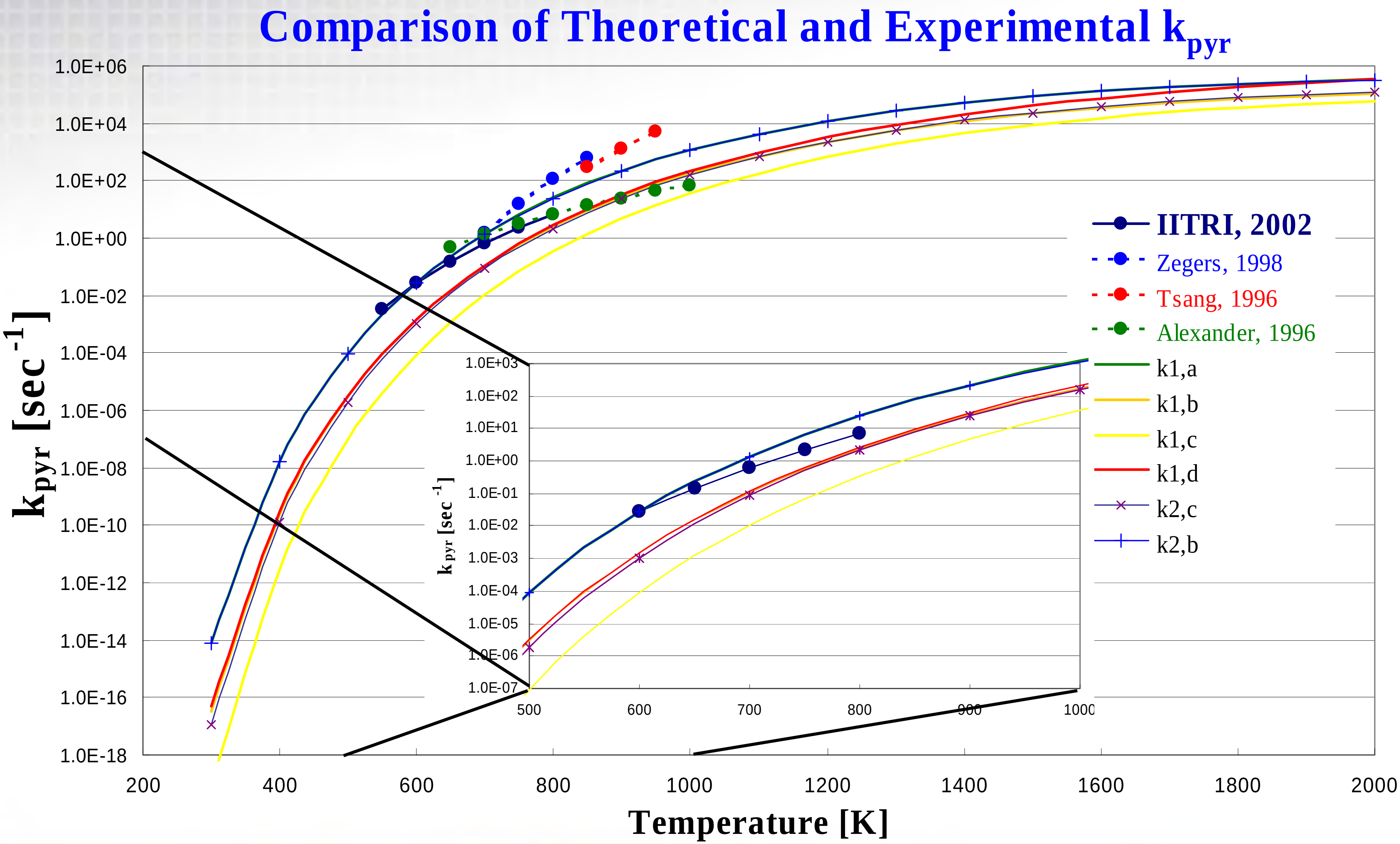


GD

MPF



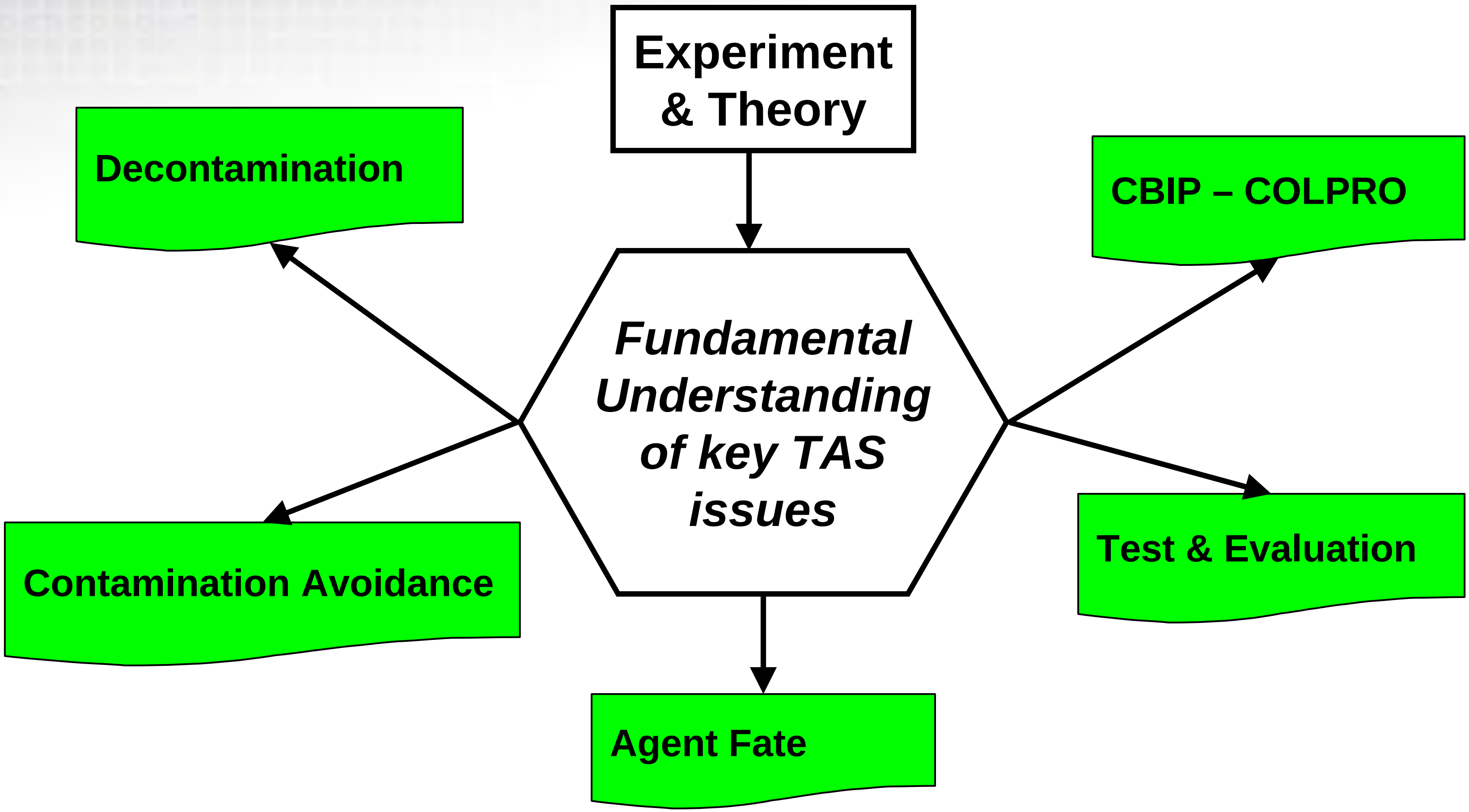
Source Terms: MBLM (Develop Input Data)



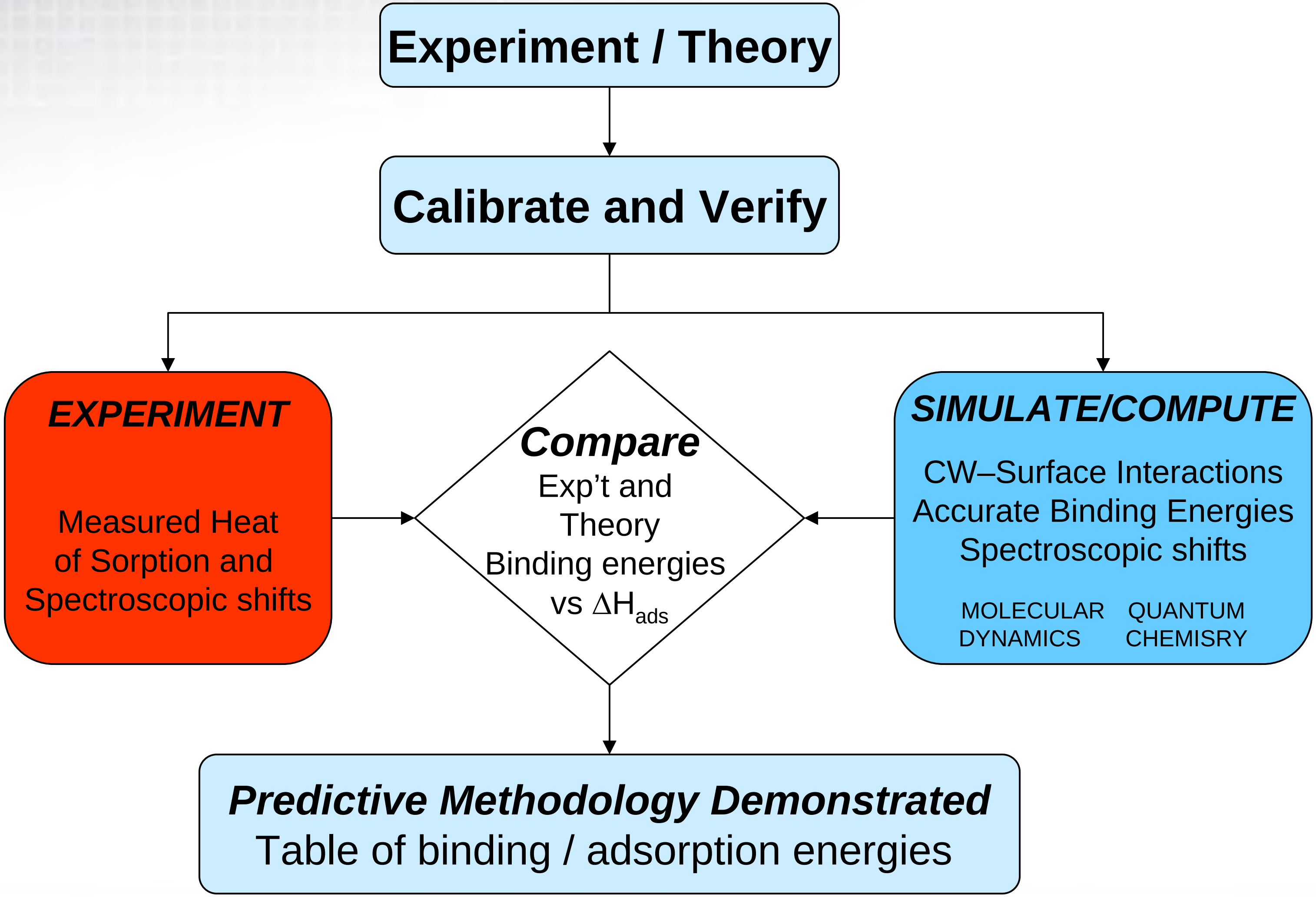
Source Terms: MBLM (Develop Input Data)

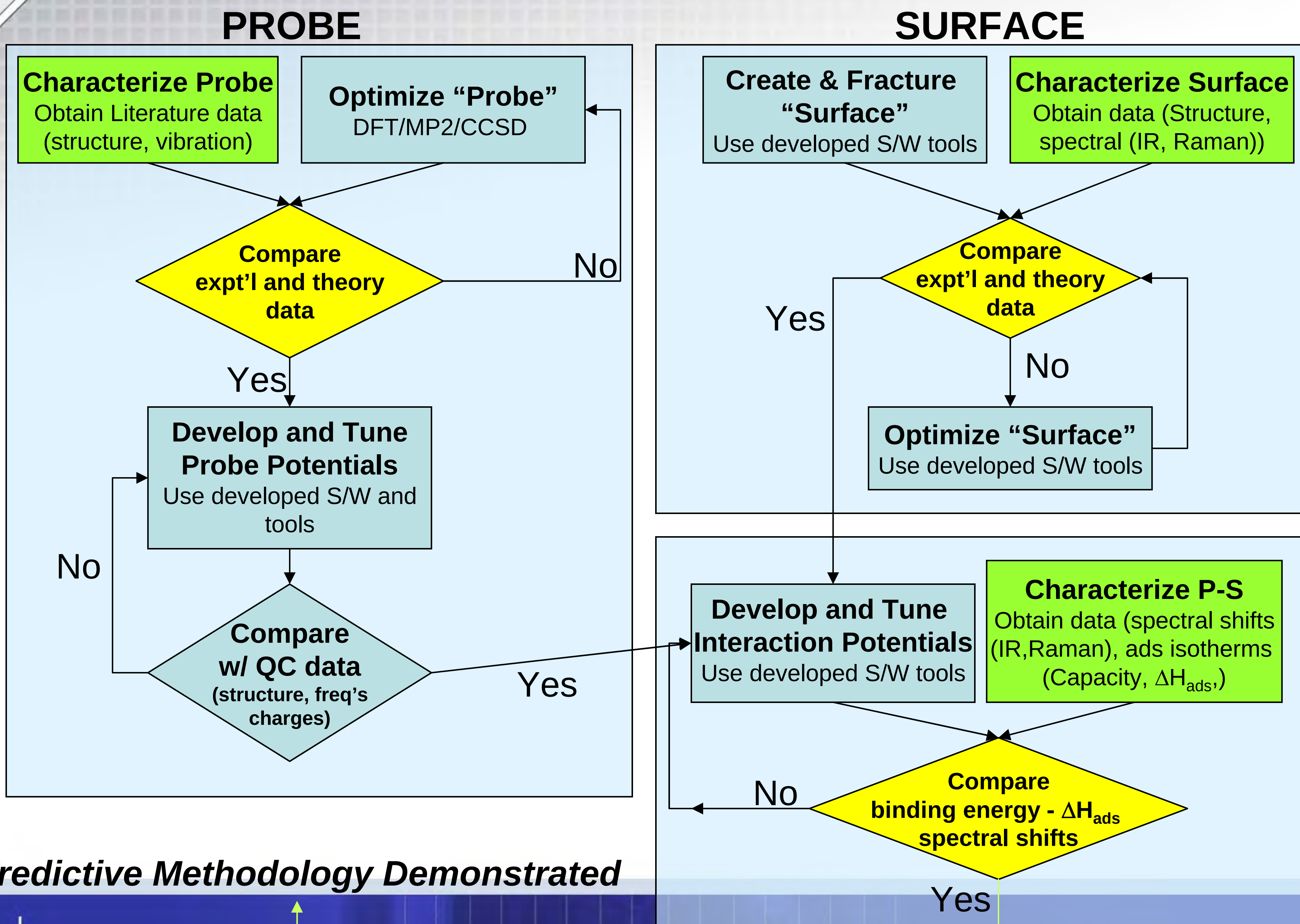
- **Pyrolysis**
  - Used theory to help *design and guide experiments*
  - Theoretical
    - TEP – 2 Pathways (300 – 2000 K)
    - GD – 1 Pathway (300 – 2000K)
    - Non-Arrhenius Kinetics
    - **300K**
  - Experimental
    - TEP – 1 overall k (600 – 800 K)
    - Arrhenius kinetics
    - **1000K**
- **Hydrolysis**
  - Developed mechanism for TEP involving water dimer
- **Thermodynamics**
  - H_{pyr} and H_{comb} were determined from QC calculations and equilibrium calcs

Computational Chemistry
Surface Chemistry



J Comp Aided Design Materials, Oct 2006, Vol 13

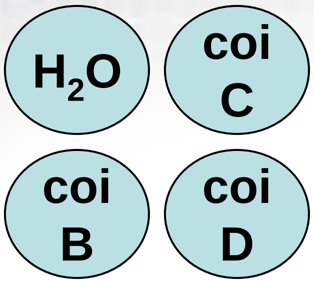


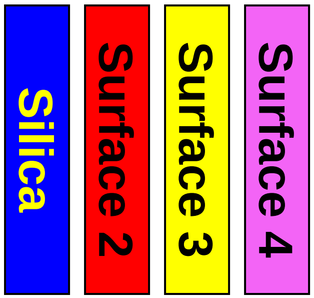


Predictive Methodology Demonstrated

INTERACTING PROBE – SURFACE

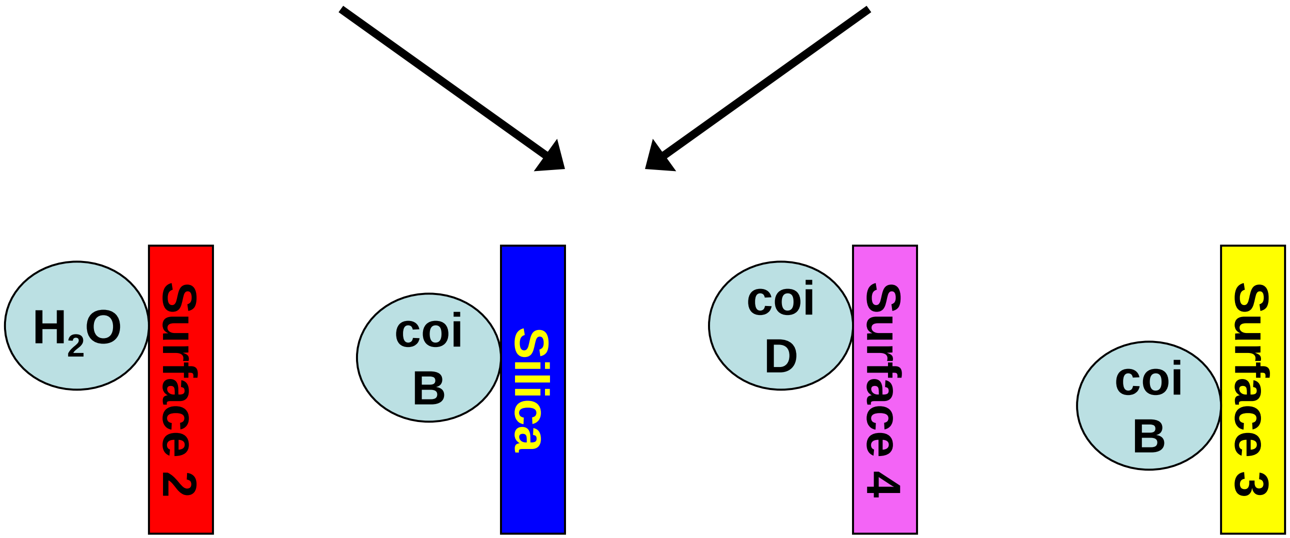
Theoretical Investigation of Cmpd-Surface Interactions





Build Library of COI's

Build Library of Surfaces



Build Library of "Interaction Potentials"

Theoretical Investigation of Cmpd-Surface Interactions (with Experimental Validation)

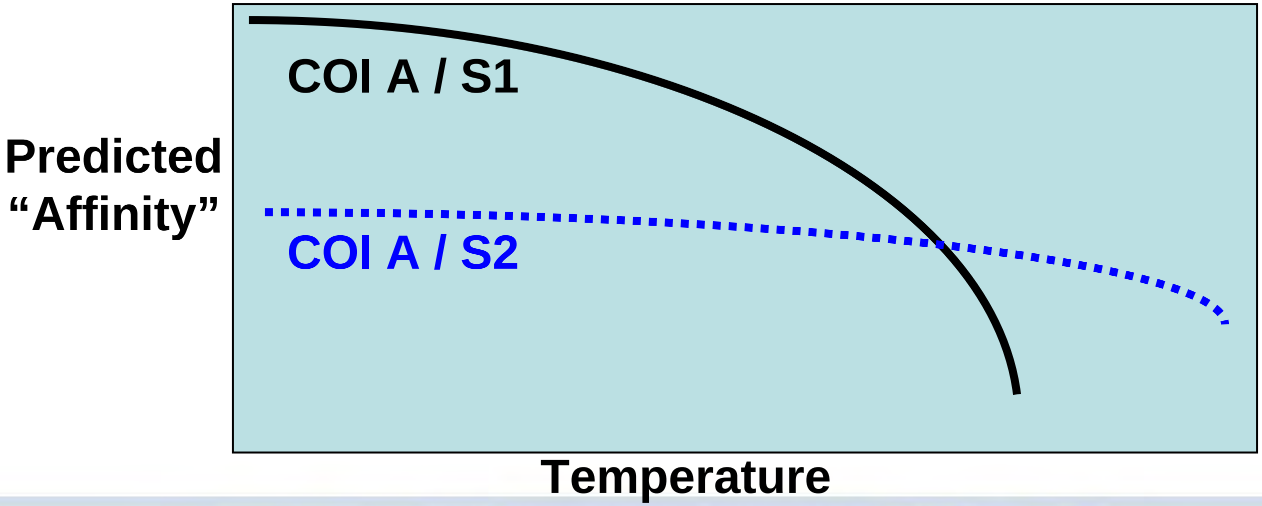
Predictive Methodology Demonstrated
Table of binding / adsorption energies

Table of binding / adsorption energies

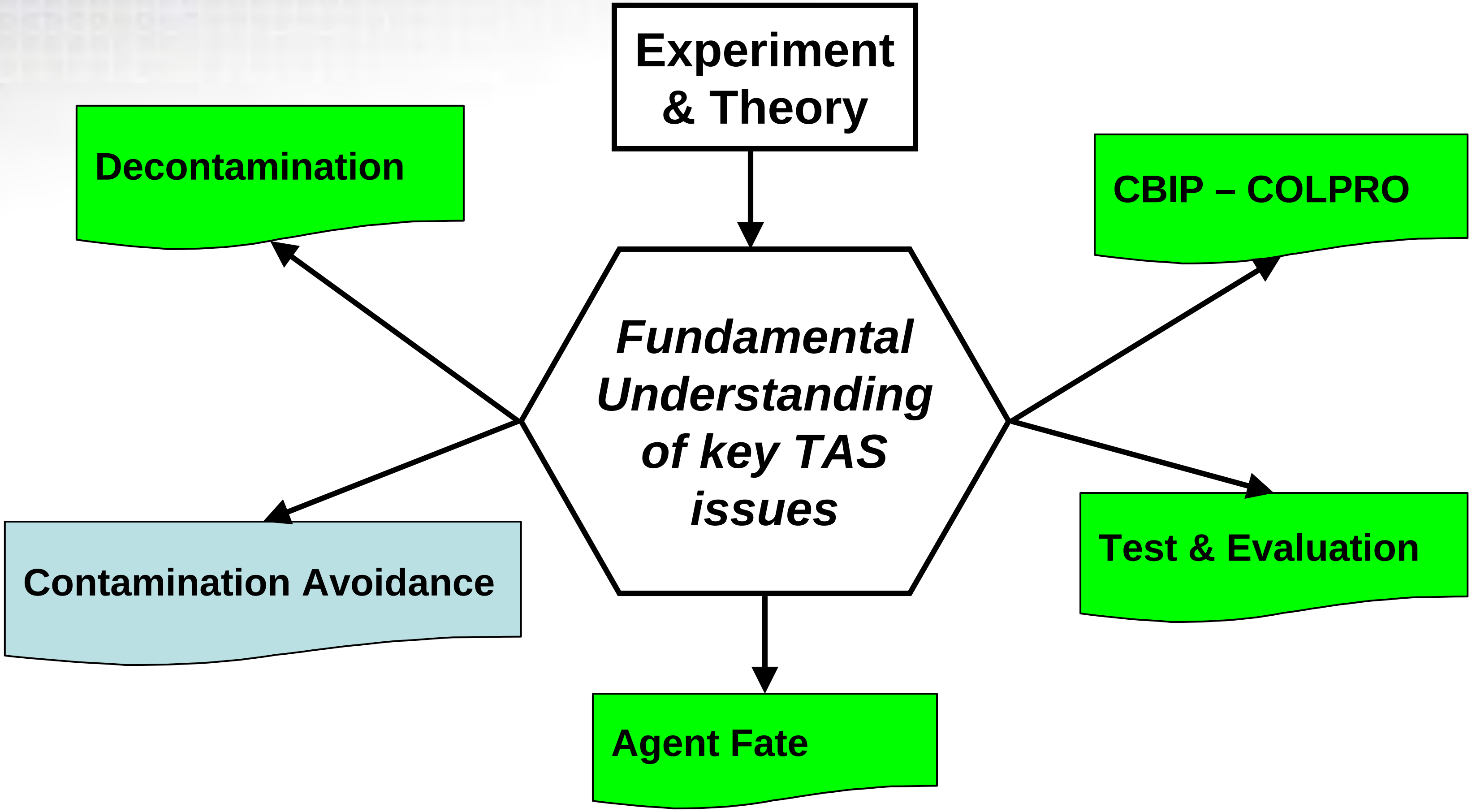
Surface / Compound	1	2	3	4
A	8	4	4	2
B	2	2	3	15
C	1	5	10	1

Benefits of Modeling

- *Understanding* Adsorption
  - Provides insight and understanding into **critical parameters** driving experimental results. For example:
    - How does temperature affect the experiment?
    - How does humidity affect the experiment?
  - Economical use of experimental resources.
- Validated Models
  - Facilitate extrapolation to new COIs and materials
  - Improved design of experiments



Computational Chemistry
Physical Properties



Product Test and Evaluation

- Analytical basis for experiments – *what variables are important*
- Scalability to real-world scenarios
- Simulants selection

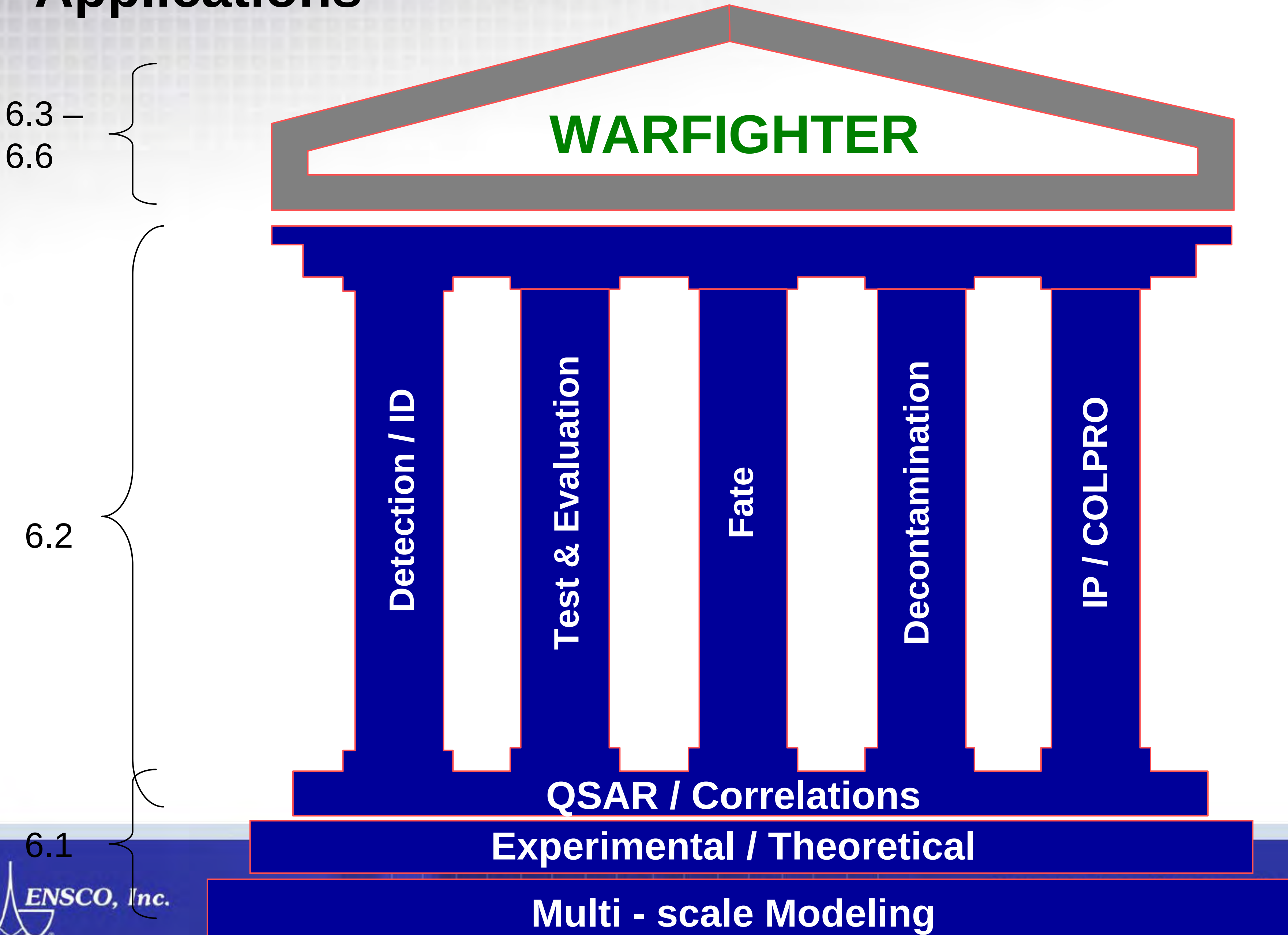
BENCH
(controlled)

CHAMBER

FIELD

Increase in variables & decrease in control

Applications



ENSCO, Inc.

Joint Project Manager Information Systems (JPM IS) Overview

CBIS

January 2007

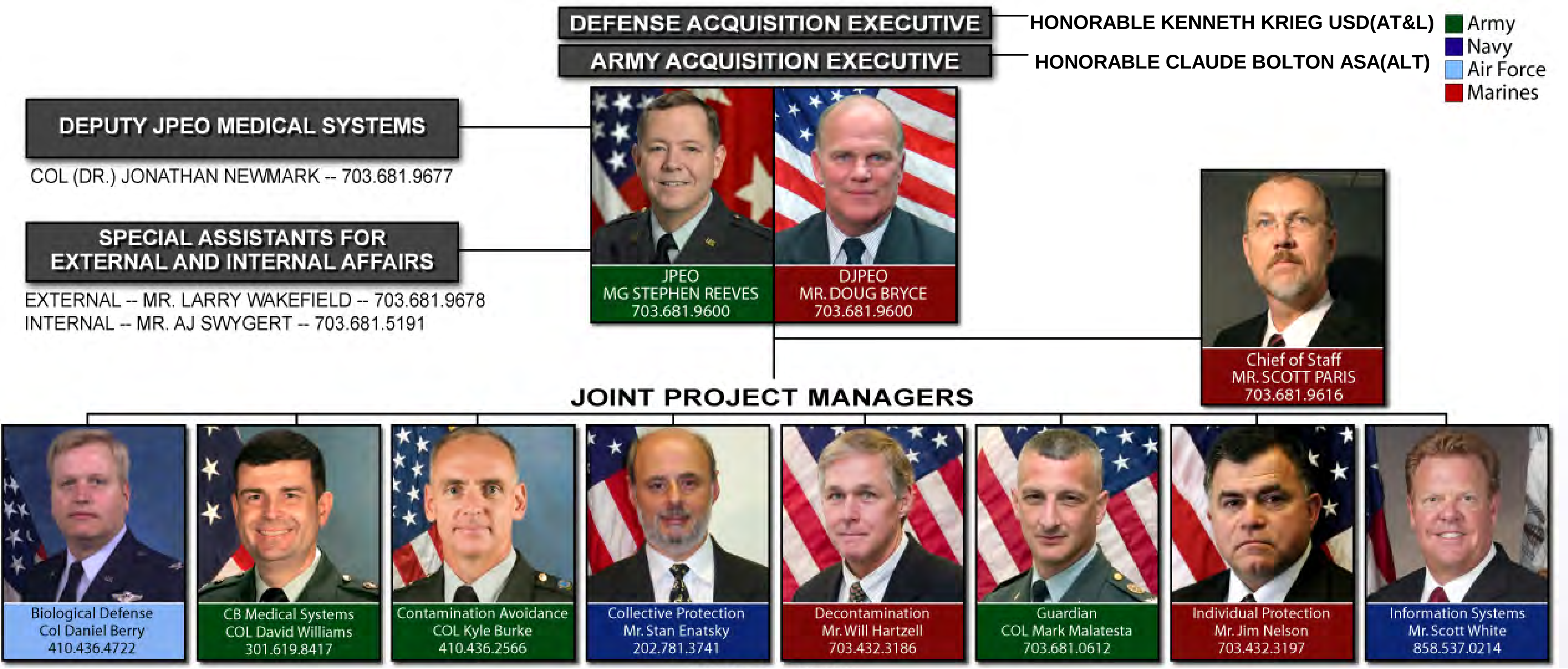
Scott White
JPM Information Systems
Joint Program Executive Office
for Chemical and Biological Defense
scott.white@jpmis.mil

Agenda

- JPM IS Overview – Mr. Scott White
  - Organizational changes
  - Program Overview
  - CY 06 Accomplishments
  - JSTO partnership
  - Business Opportunities

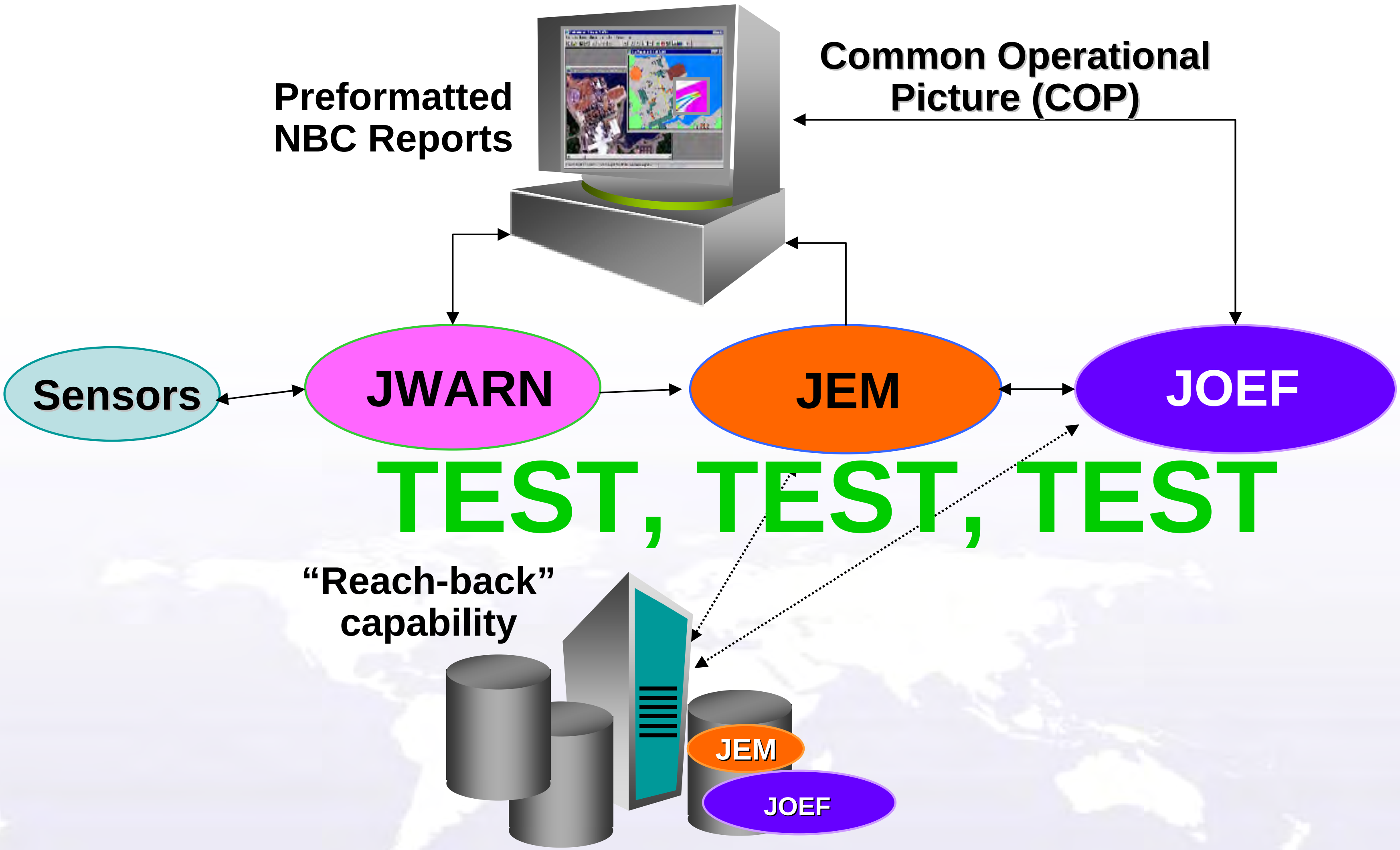
- Joint Effects Model (JEM) – Mr. Thomas Smith
- Joint Operational Effects Federation (JOEF) – Ms. Kathy Houshmand
- Joint Warning and Reporting Network (JWARN) – CDR Mike Steinmann
- JPM IS Software Support Activity (SSA) – Mr. Kevin Adams

Joint Program Executive Office for Chemical and Biological Defense



Program Overview

End-to-End Capability



JPM IS Accomplishments

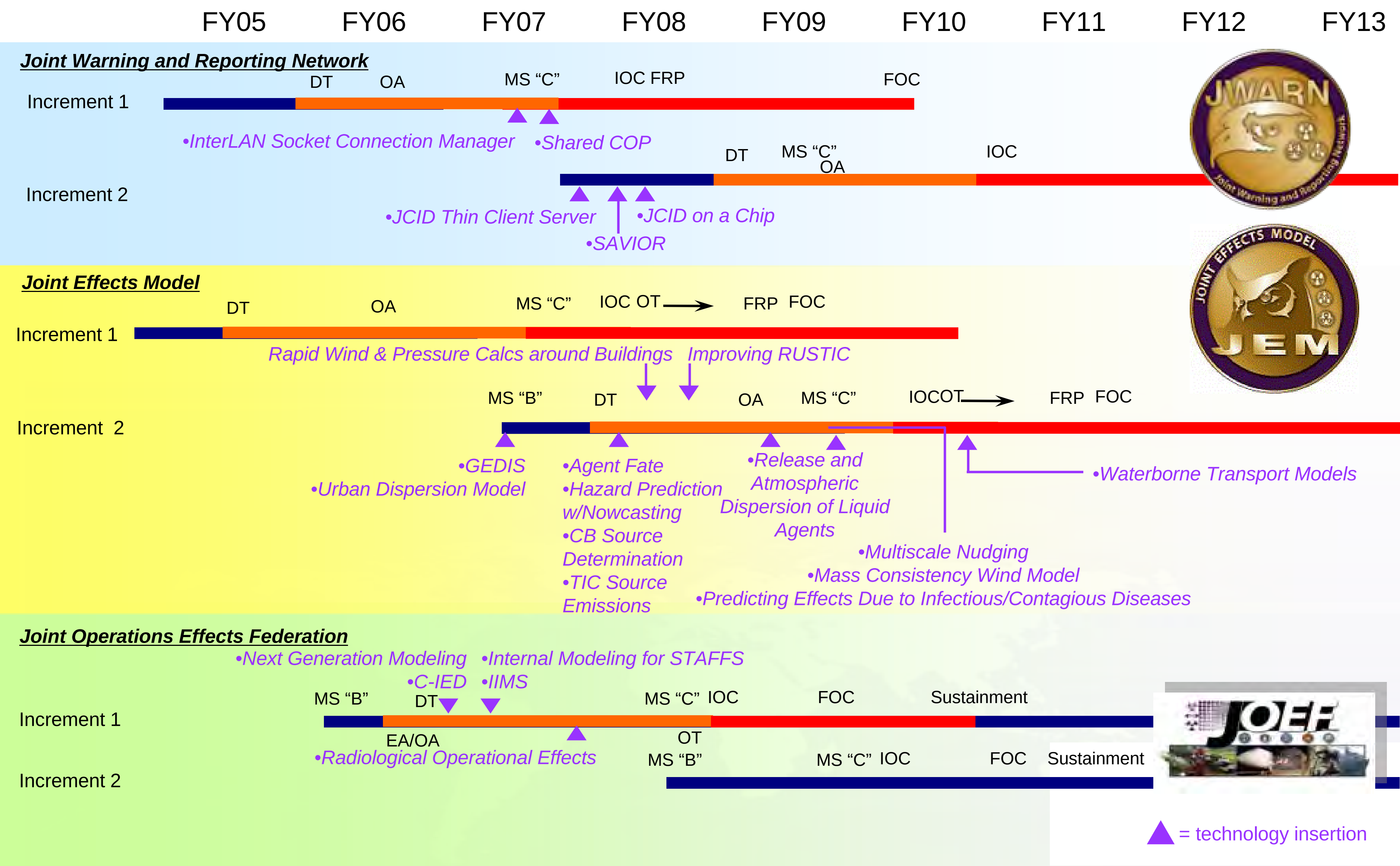
- JWARN and JEM integration into GCCS-J 4.1
- Developed, tested, and delivered an upgraded version (JWARN 1F) of the JWARN 1E system currently in wide use by OIF and OEF deployers
- Identification of Wireless technology solutions for evaluation and potential inclusion with JWARN Block One
  - Will provide sufficient coverage for typical air base
  - Supports rapid mobile dismounted deployment
  - Meets IA requirements
  - NSA certifiable
- JEM - Completed integration of 3 legacy T&D models into one SOA baseline
- JOEF development contract award to CUBIC

Partnership with JSTO

- Sensor Alert Verification for Incident Operational Response (SAVIOR)
- Shared Common Operational Picture (COP)
- JCID Thin Client Server
- InterLAN Service Connection Manager (ILSCM)
- JCID on a Chip
- Urban Dispersion Models
- Internal Modeling for STAFFs

JSTO is providing critical tech base input

Acquisition Pull: The Technology Transition Paradigm



Business Opportunities

	Time Period
• Physical Science and Technology Broad Agency Announcement (BAA)	FY06 & FY07
– December each year	
– Other BAA solicitation occurs under the CBDIF program	
• SPAWAR Knowledge Superiority (BAA)	
– JPM IS Technology Challenges/S&T Gaps	Open Indefinitely
• JWARN	
– JCID production (RFP)	FY08 – FY12
– Block 2 Increment 1 Sustainment	FY08 and beyond
– Block 2 Increment 2 Design & Development	FY08 – FY09
• JEM	
– JEM Lead Integrator (SEAPORT E)	FY07-FY12
• Sustain Block I	
• Integrate S&T Capabilities for Block II & Beyond	
• JOEF	
– JSTO Technology Insertion Increment 1	FY06 – FY08
– JSTO Technology Insertion Increment 2	FY06 and beyond
– Software Development Increment 2 and beyond	FY08 and beyond

Points of Contact

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phillip.hornick@navy.mil	
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curt.wall@jpmis.mil	
CDR Mike Steinmann, JWARN APM	(858) 537-0685
michael.steinmann@jpmis.mil	
Mr. Thomas Smith, JEM APM	(858) 537-8677
thomas.r.smith@jpmis.mil	
Dr. Jerry Hoffman, JOEF APM	(858) 537-0125
jerome.hoffman@navy.mil	

A Modular Architecture for Multivariate Investment Decision Support

Shan Xia[1], Panaiotis[1], Steven A. Smith[2], William Ogden[3], Jim Cowie[3], Frank Gilfeather[1], Thomas P. Caudell[1]

[1]University of New Mexico,

[2]Los Alamos National Laboratory,

[3]New Mexico State University

11 January 2007

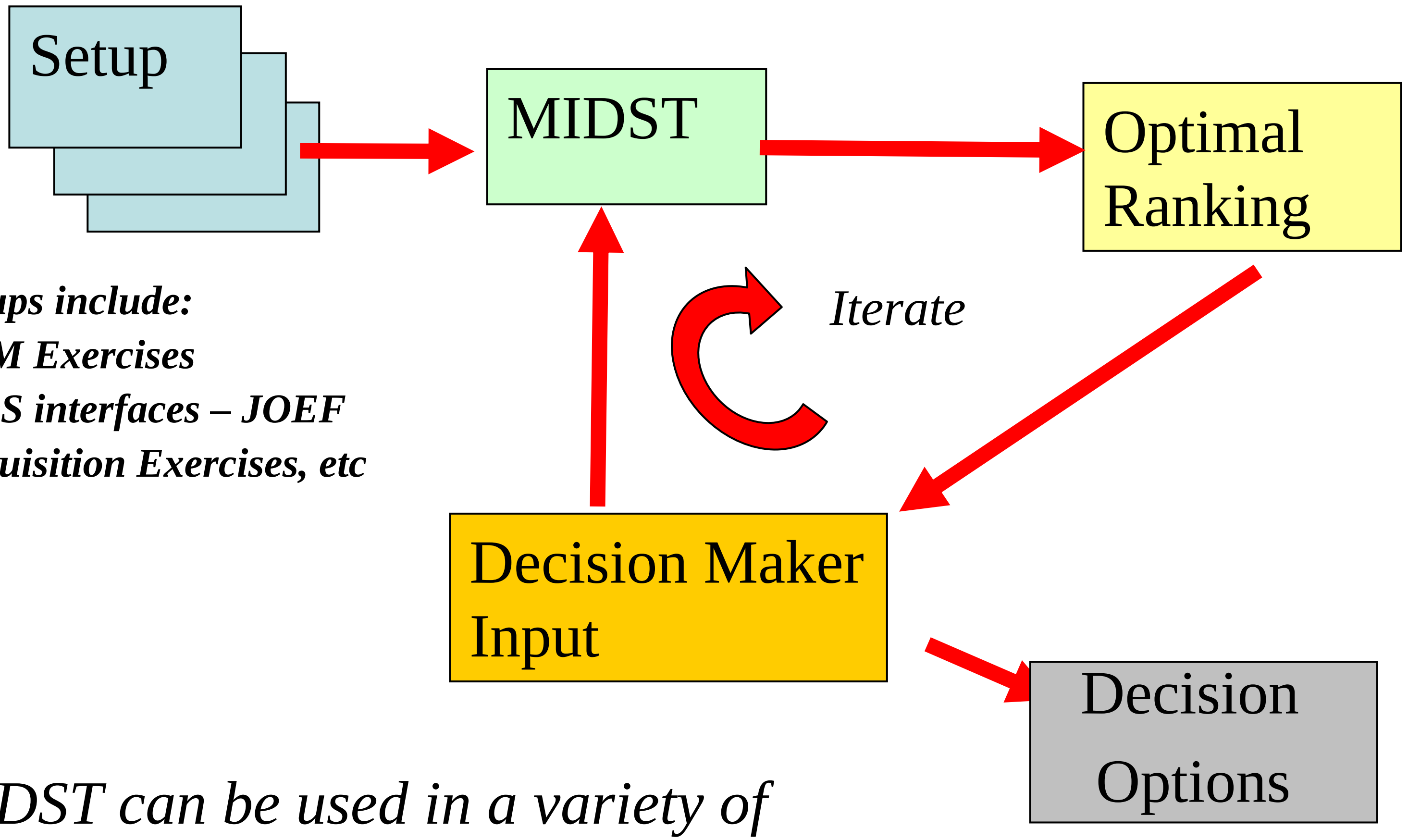
MIDST Goals

- Develop the analytic and algorithmic framework for a tool, the Multivariate Investment Decision Support Tool (MIDST), which assists decision-makers who manage funding programs or portfolios intended to minimize threat-consequences
- Create a feasible system architecture to evaluate modeling, analysis approaches, and user interactions within this framework
- Develop exercises utilizing MIDST analysis

MIDST Design Philosophy

- Utility to the decision maker
  - Tied to key user profiles - flexible in use
  - Used iteratively to fine tune decisions
- Transparency, not a black box
  - Shows the evolutionary process of derived outcomes
  - Illustrates cause and effect relationships through visualization
- Looking for “unexpected outcomes”
  - Adds information – not just obvious outcomes
  - Minimizes the effect of preconceived notions and biases
  - Provides new ideas and perspectives of the problem space
- Tuning is evolutionary
  - Capable of correcting and learning from false outcomes
  - Tool improves with use
- Use in exercises - macro or micro mode
  - High level table top use – at Agency or Program level
  - Capable of integration with JOEF or BioDAC or other M &S incident tools

Use of MIDST



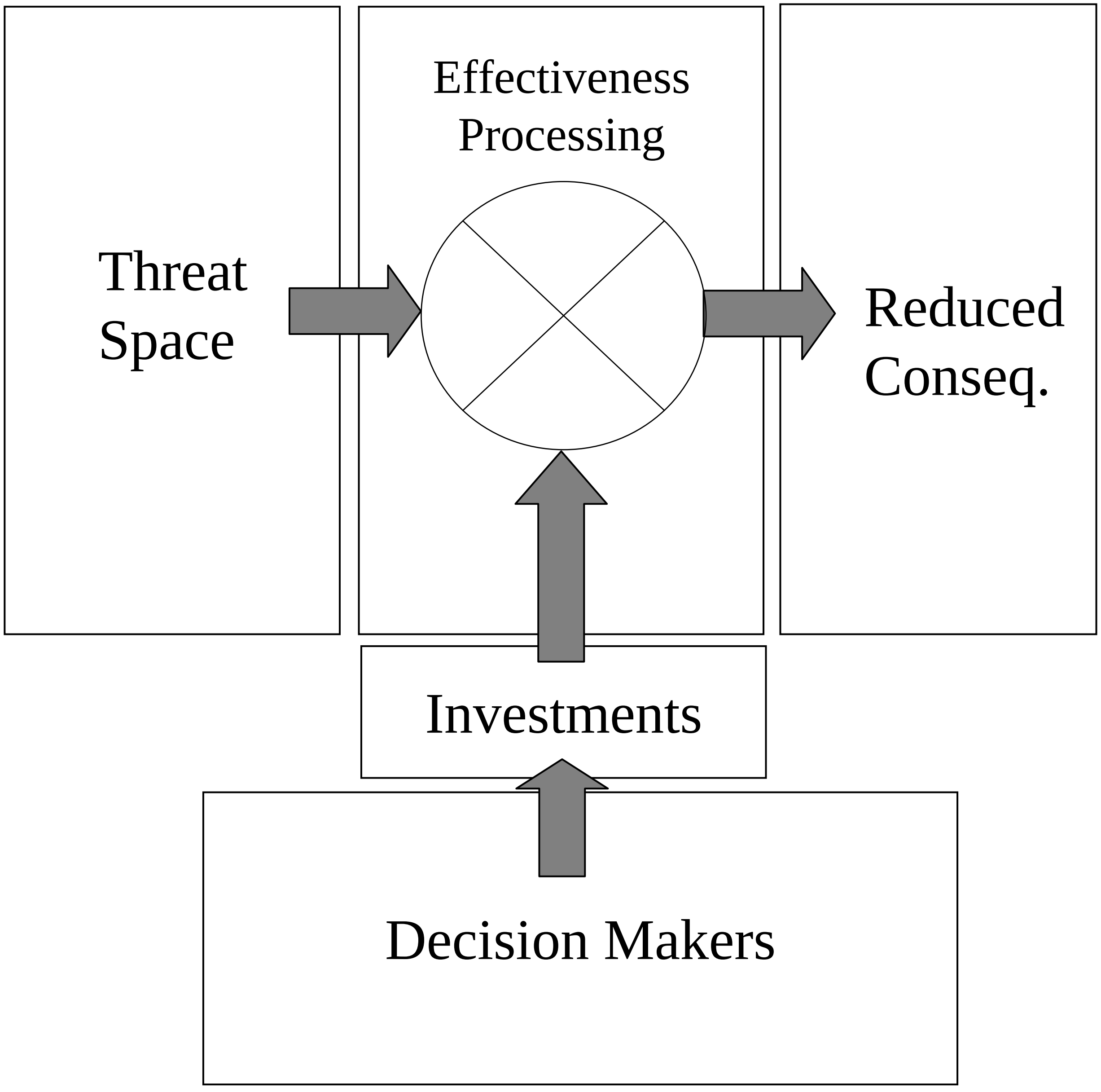
Setups include:
POM Exercises
M&S interfaces – JOEF
Acquisition Exercises, etc

MIDST can be used in a variety of exercises. Each use returns multiple decision options.

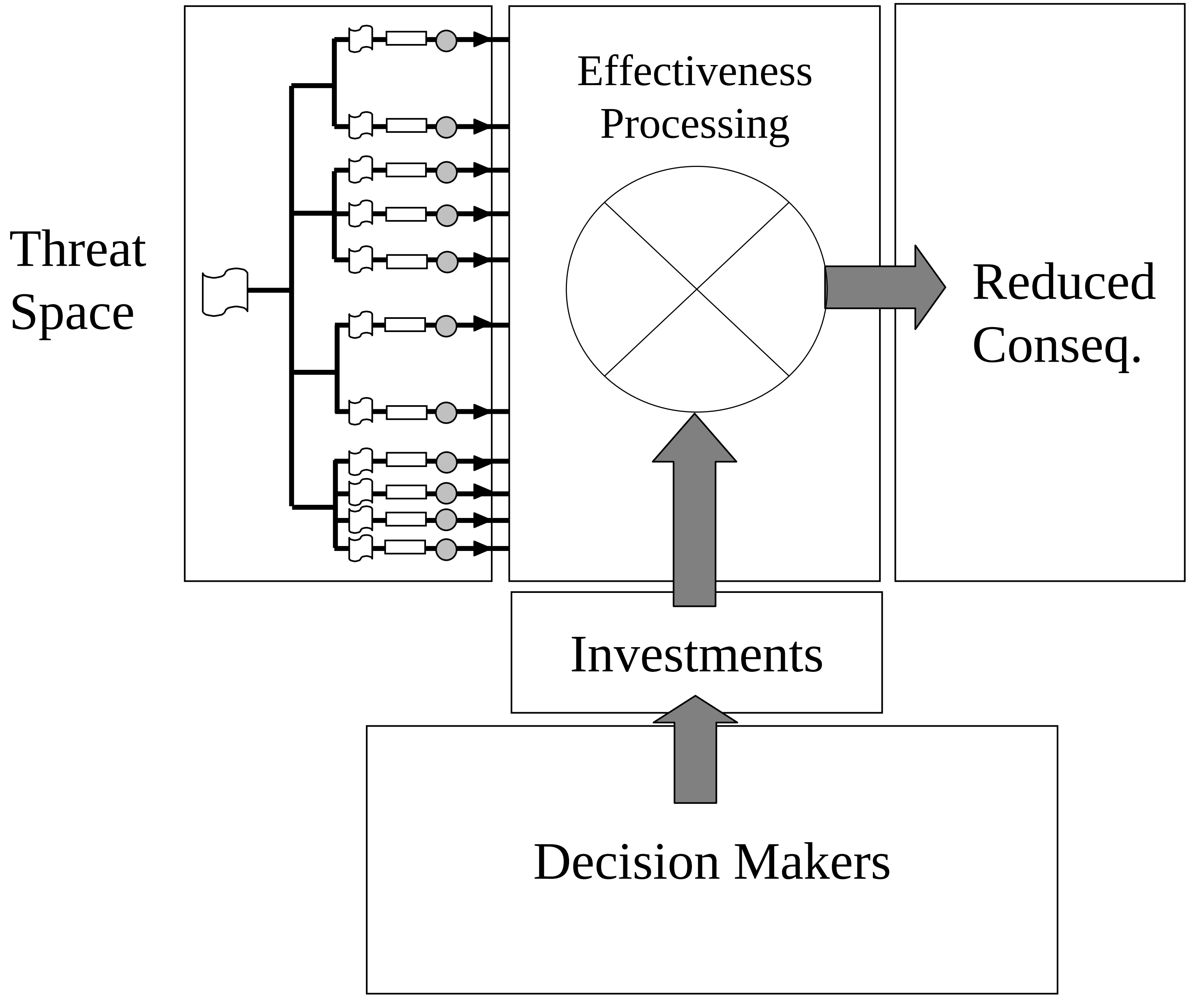
MIDST Functionality

- Interfaces
- Databases
- Analysis
- Optimization
- Visualization
- Interactivity
- Logging
- Report Generation

Architecture

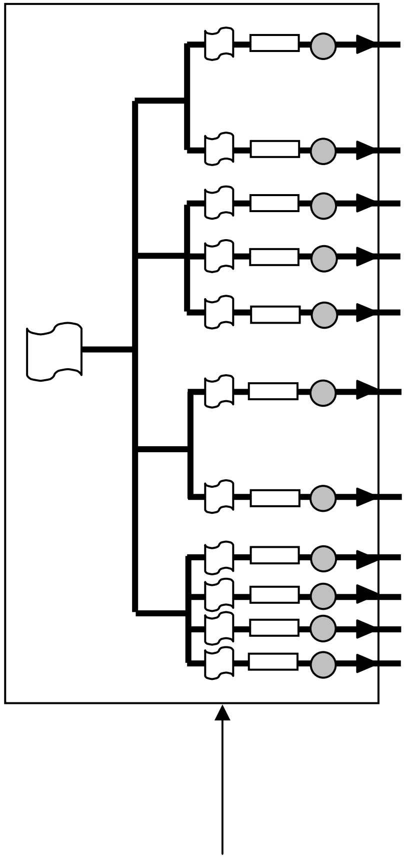


Architecture



Threat Event Model

Threat Space

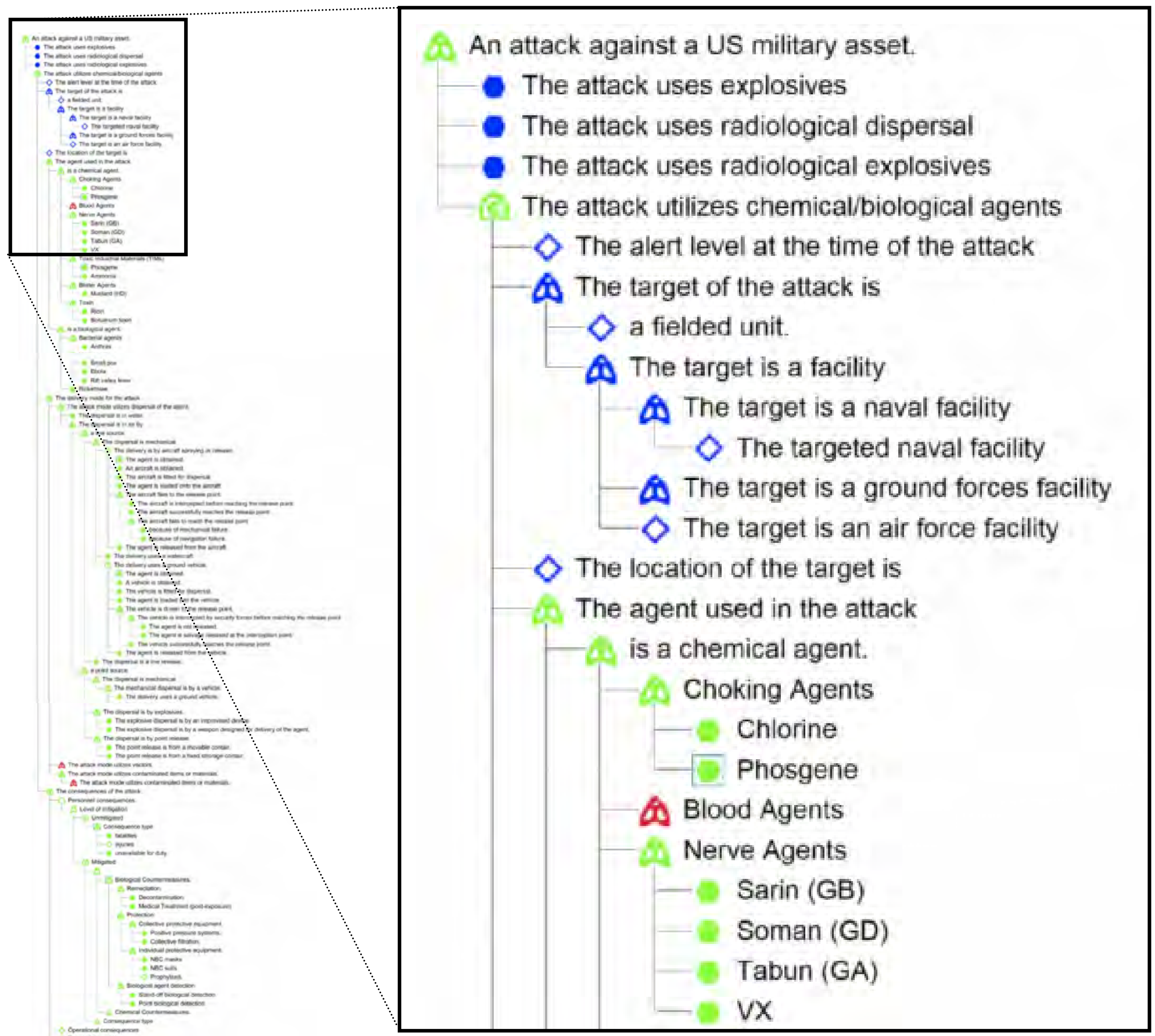


Prototype Event Set

- Possibility tree for Event Space
- Prototypes of event classes for analysis
- Multiple components of consequence
- A single event is a set of choices in tree

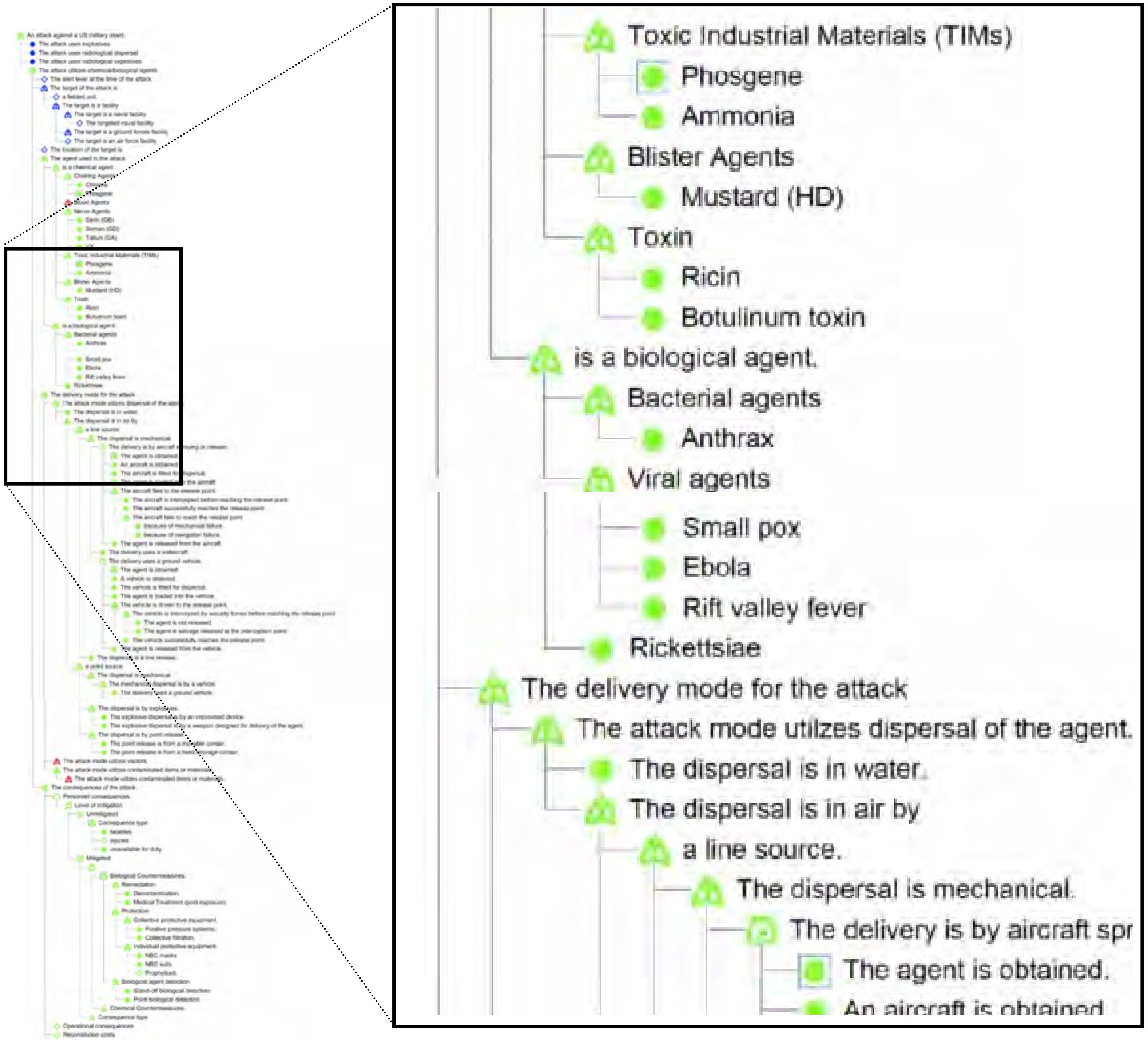
Threat Event Model

One Threat
Event
In
Possibility
Tree



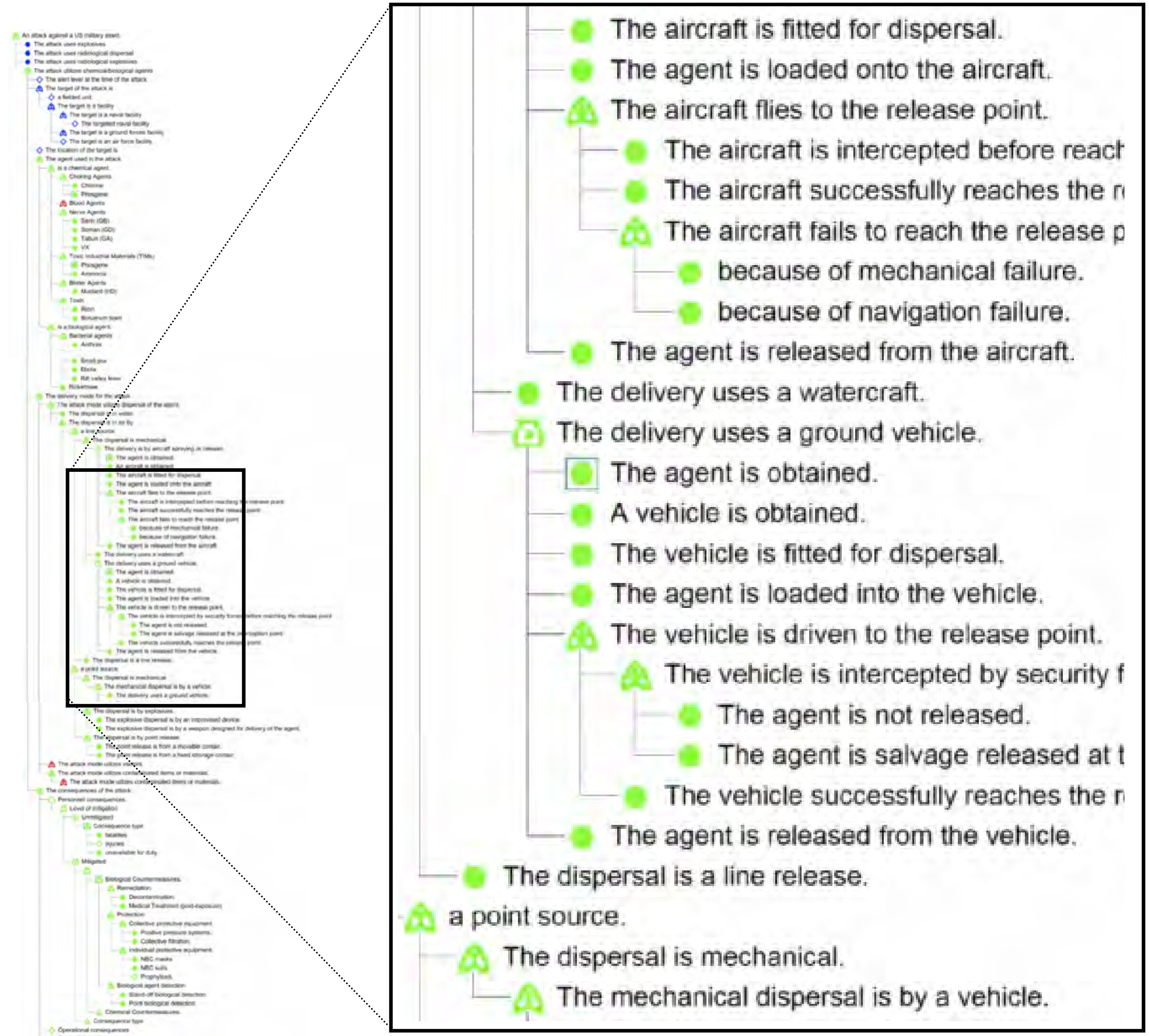
Threat Event Model

One Threat Event In Possibility Tree



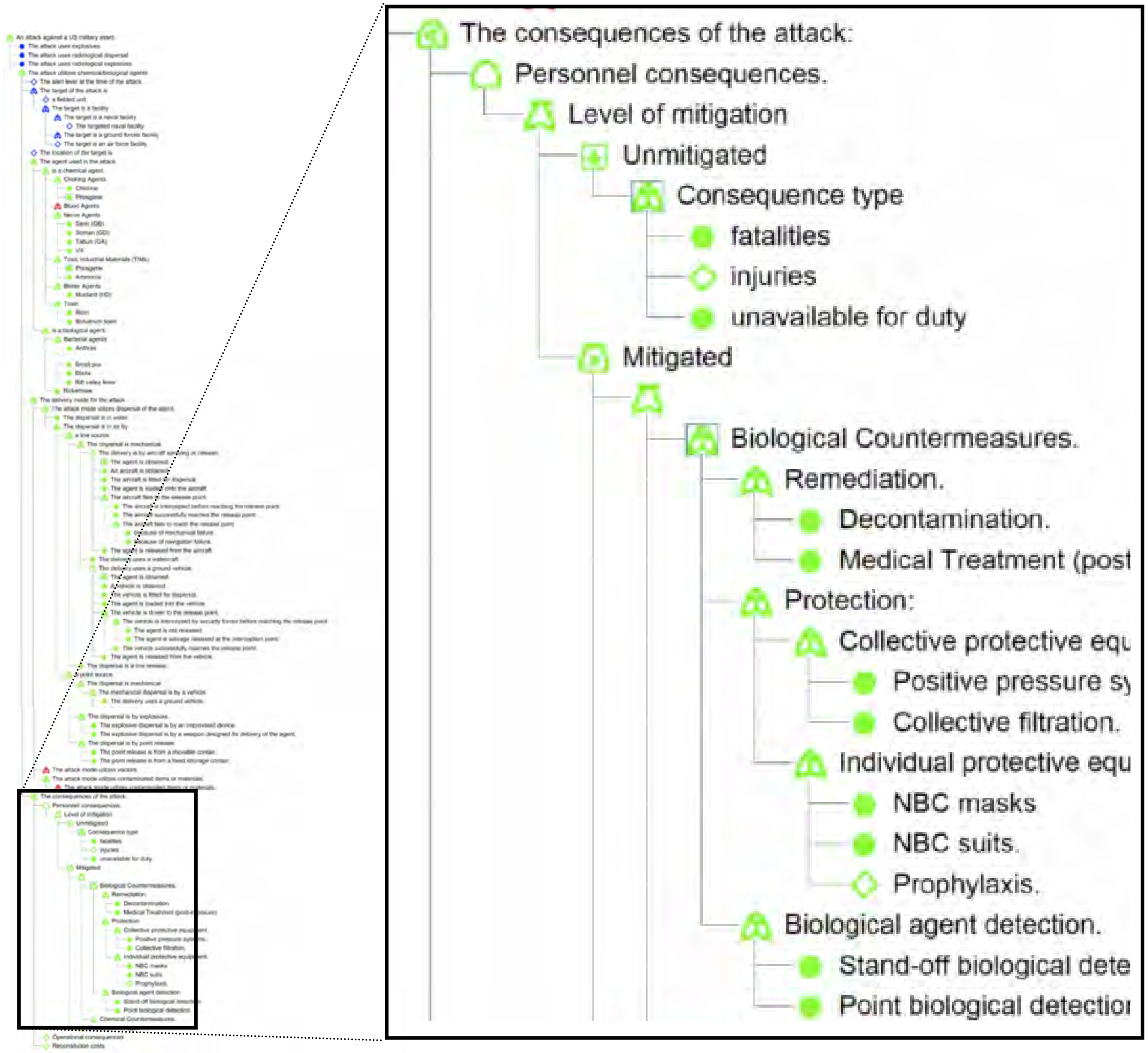
Threat Event Model

One Threat
Event
In
Possibility
Tree



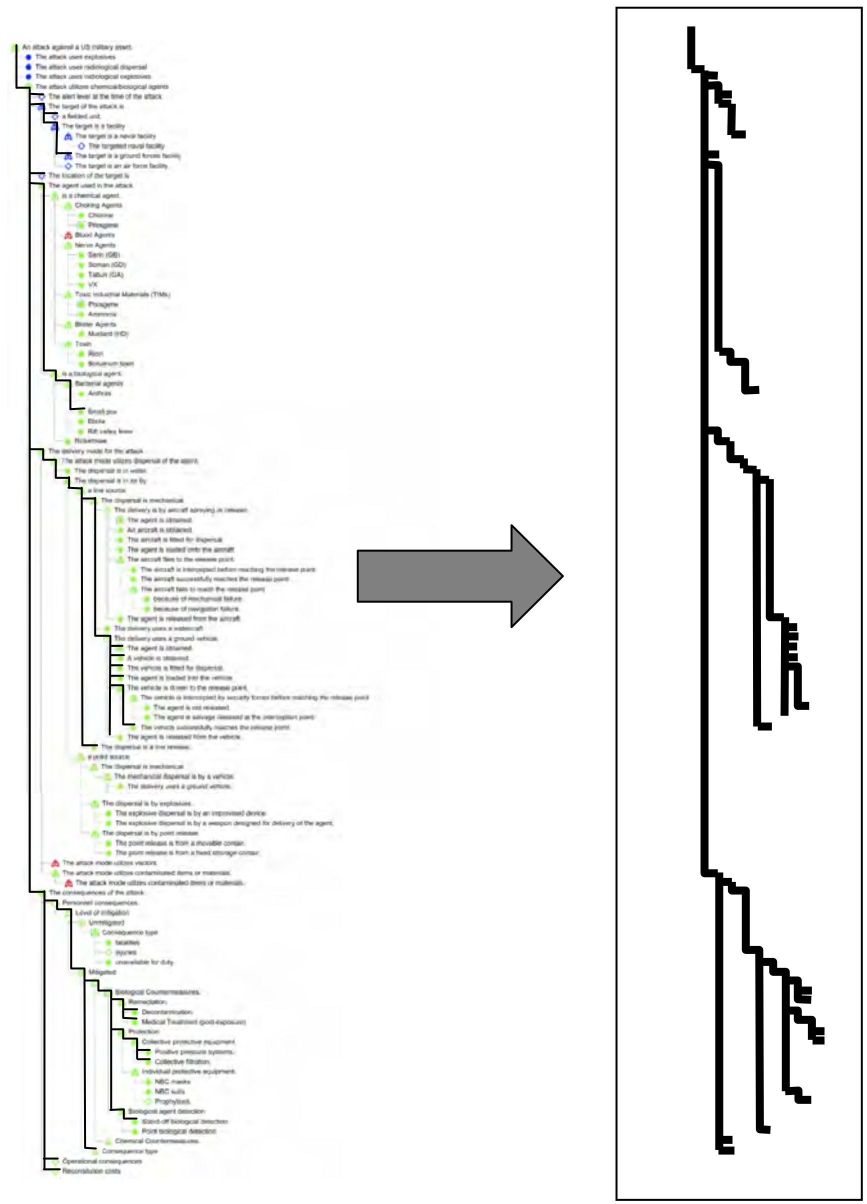
Threat Event Model

One Threat Event In Possibility Tree

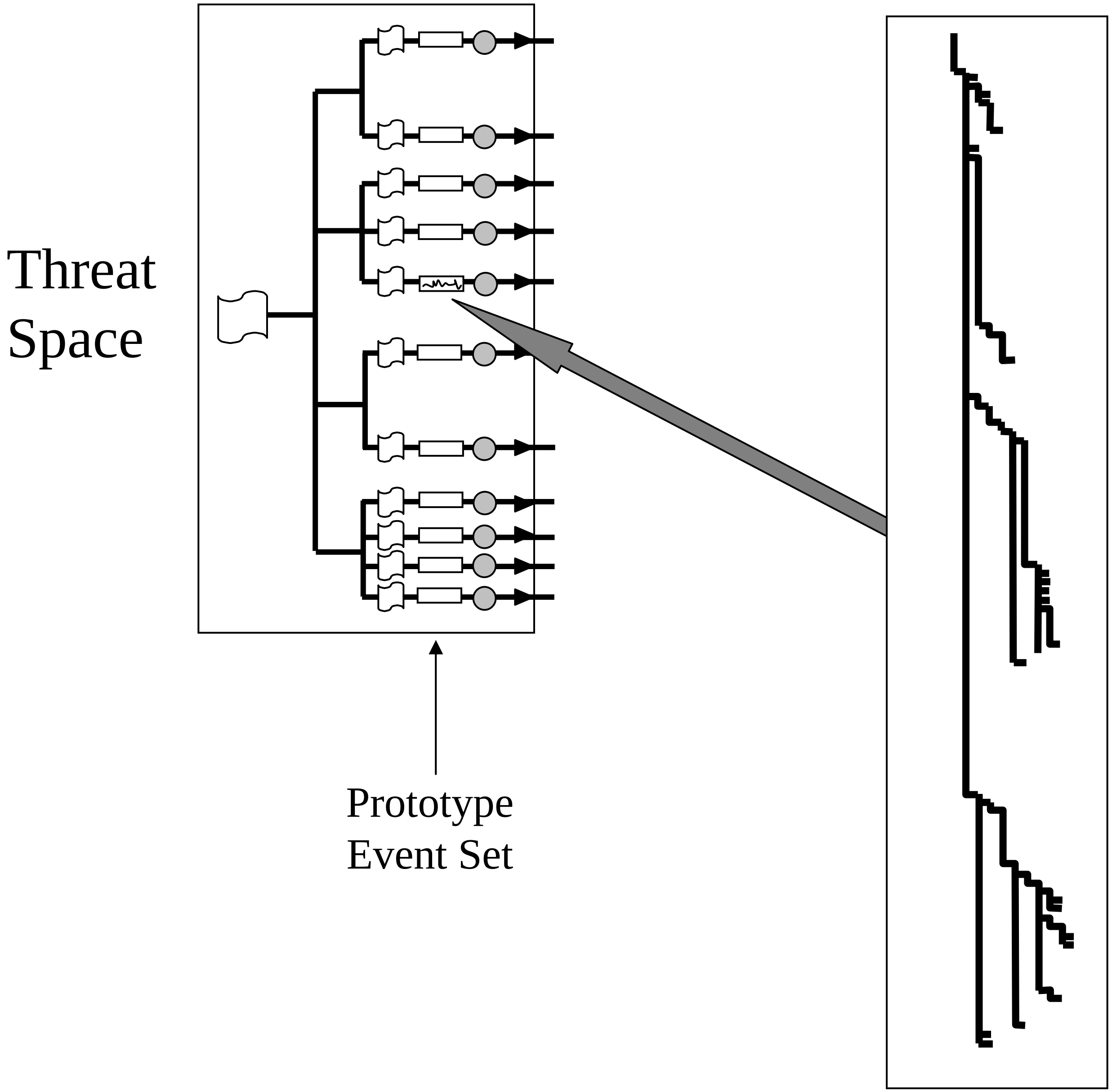


Threat Event Model

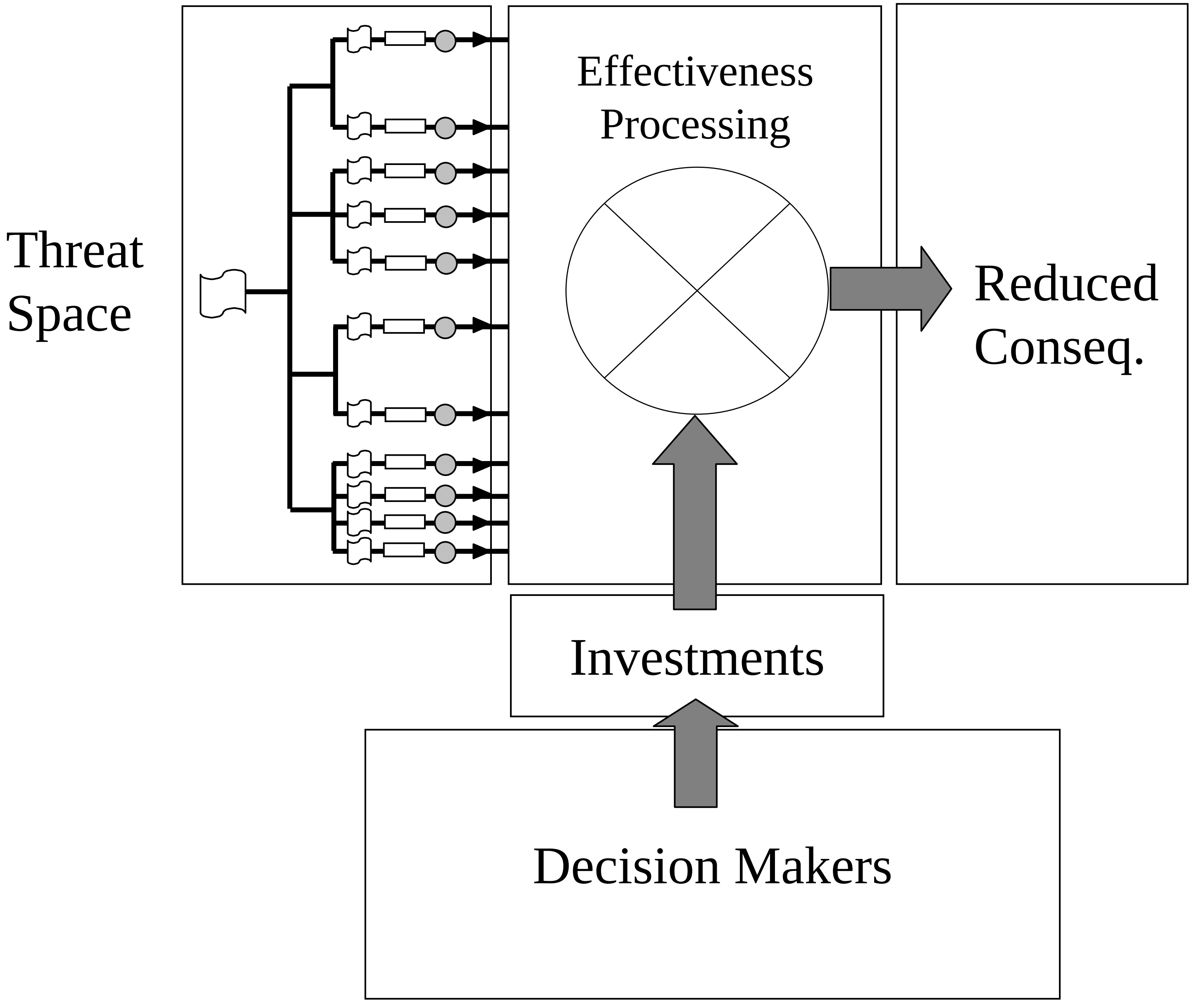
One Threat Event In Possibility Tree



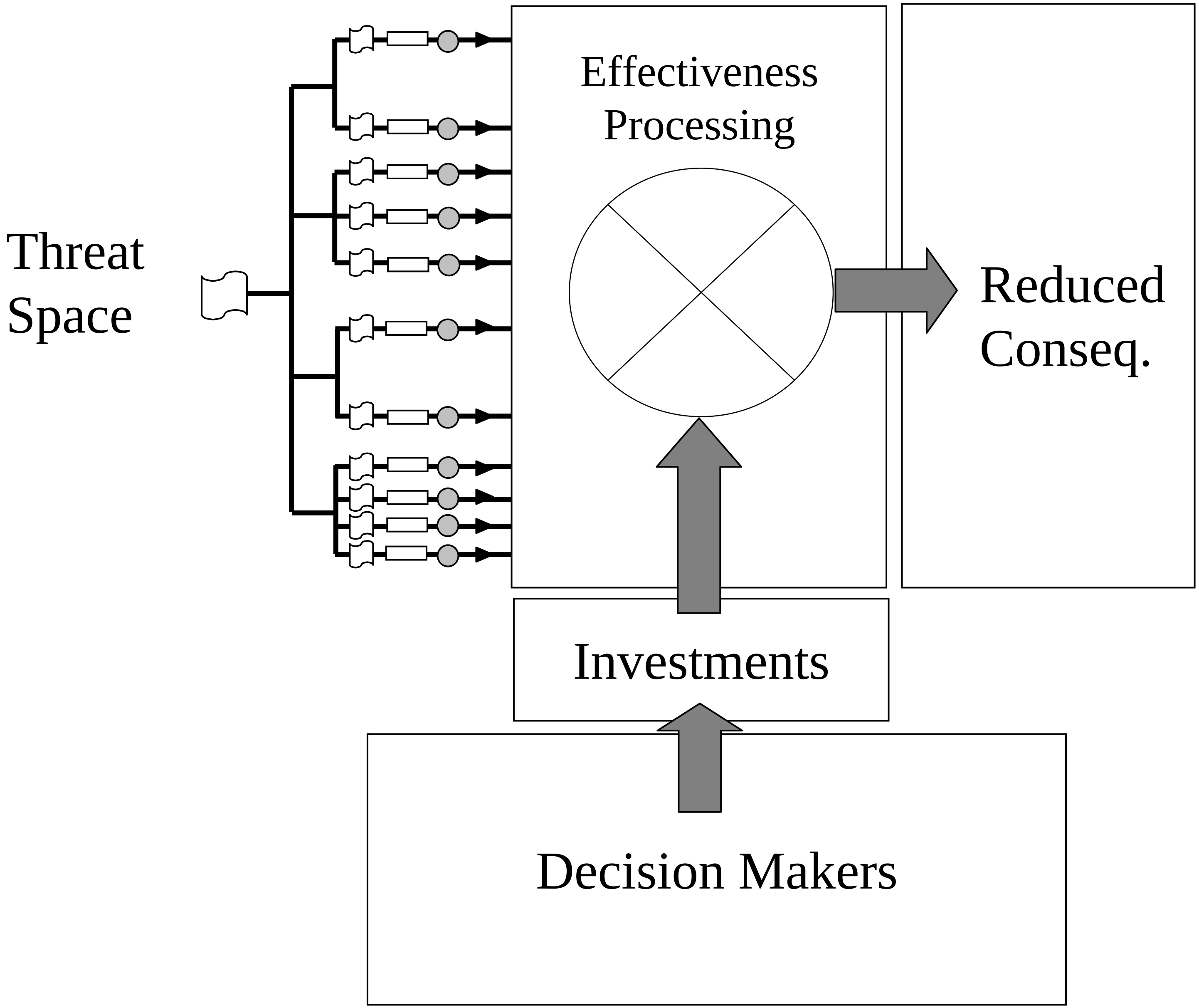
Threat Event Model



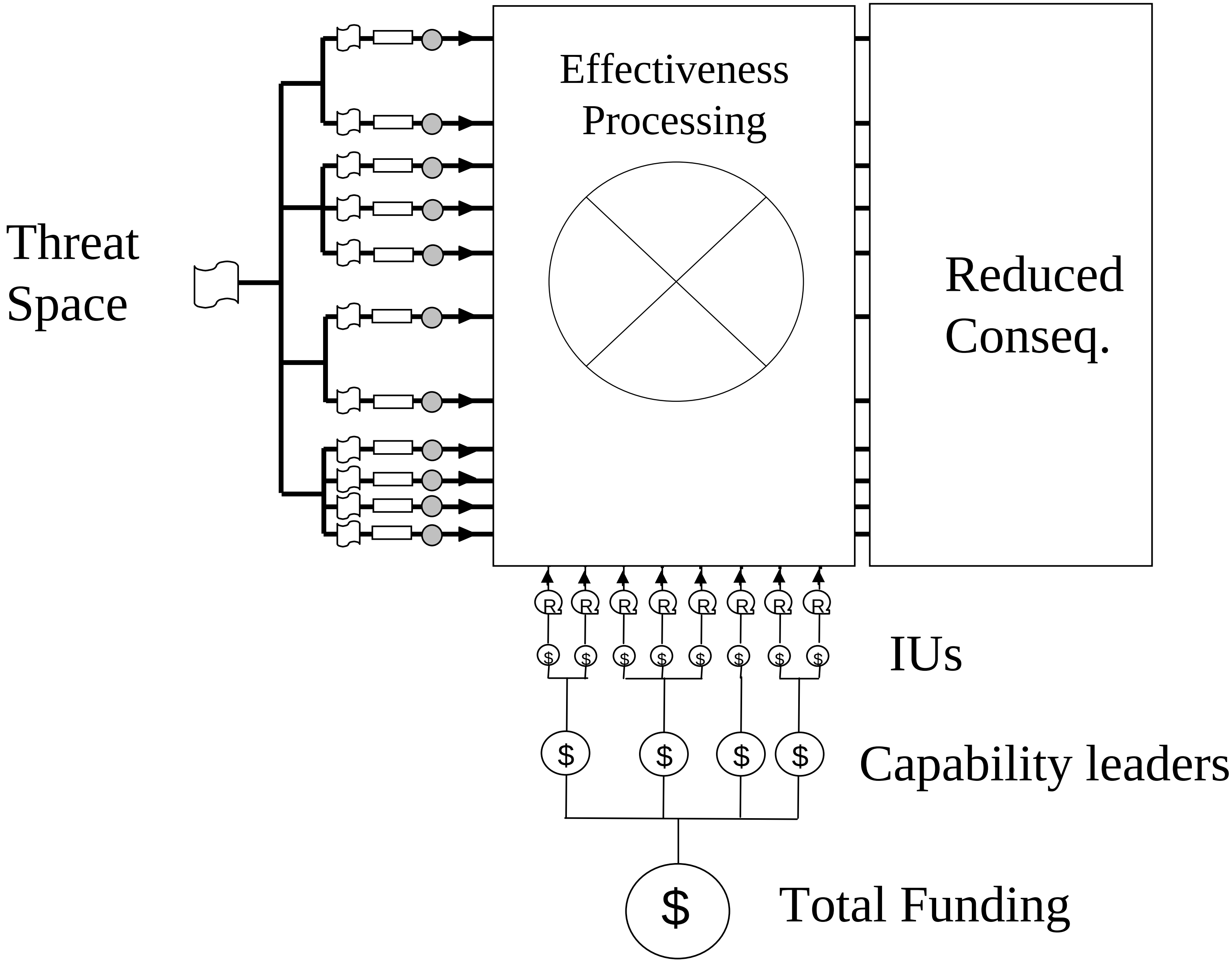
Architecture



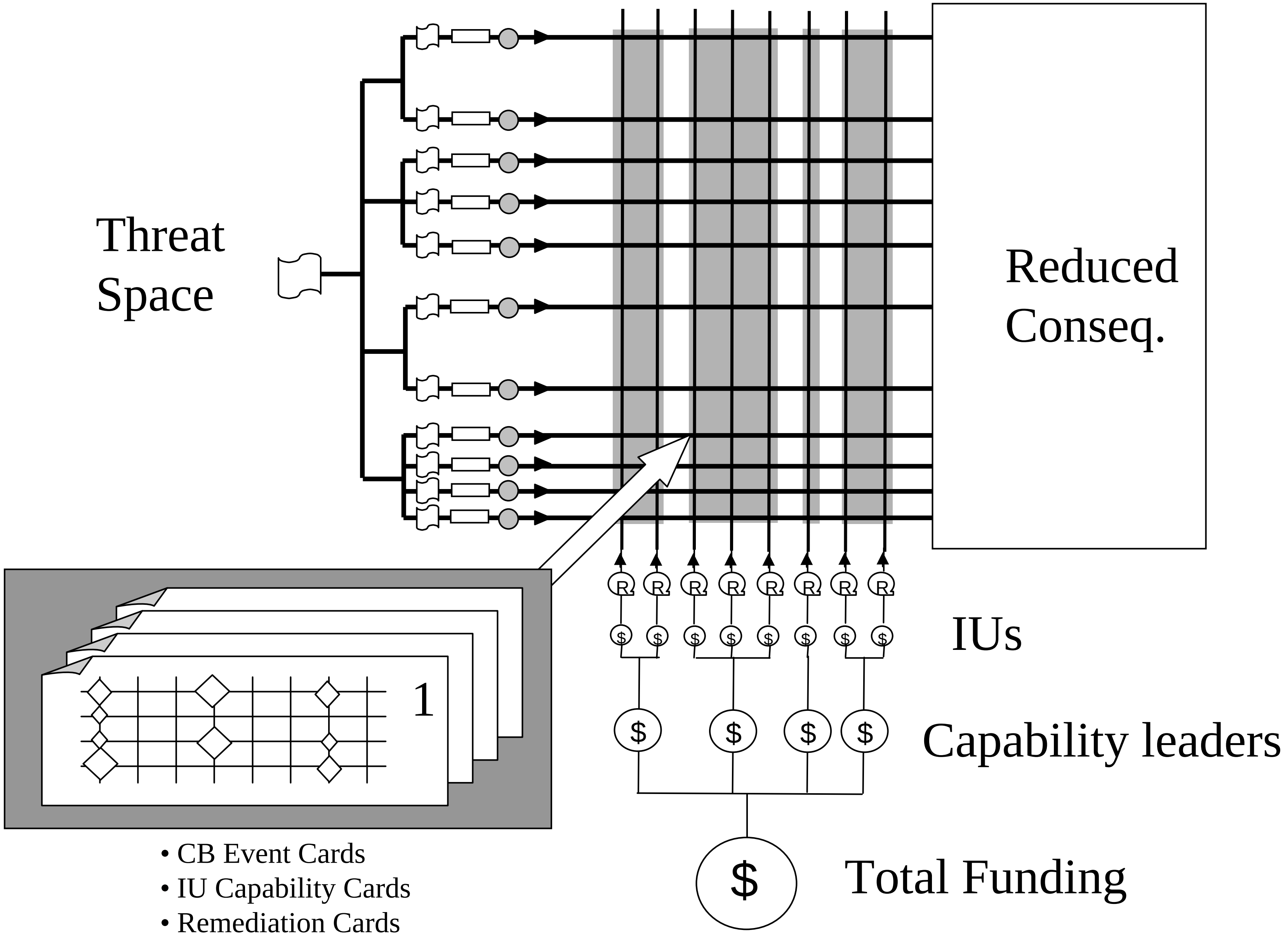
Decision Makers and Investments



Capability leaders and Effectiveness

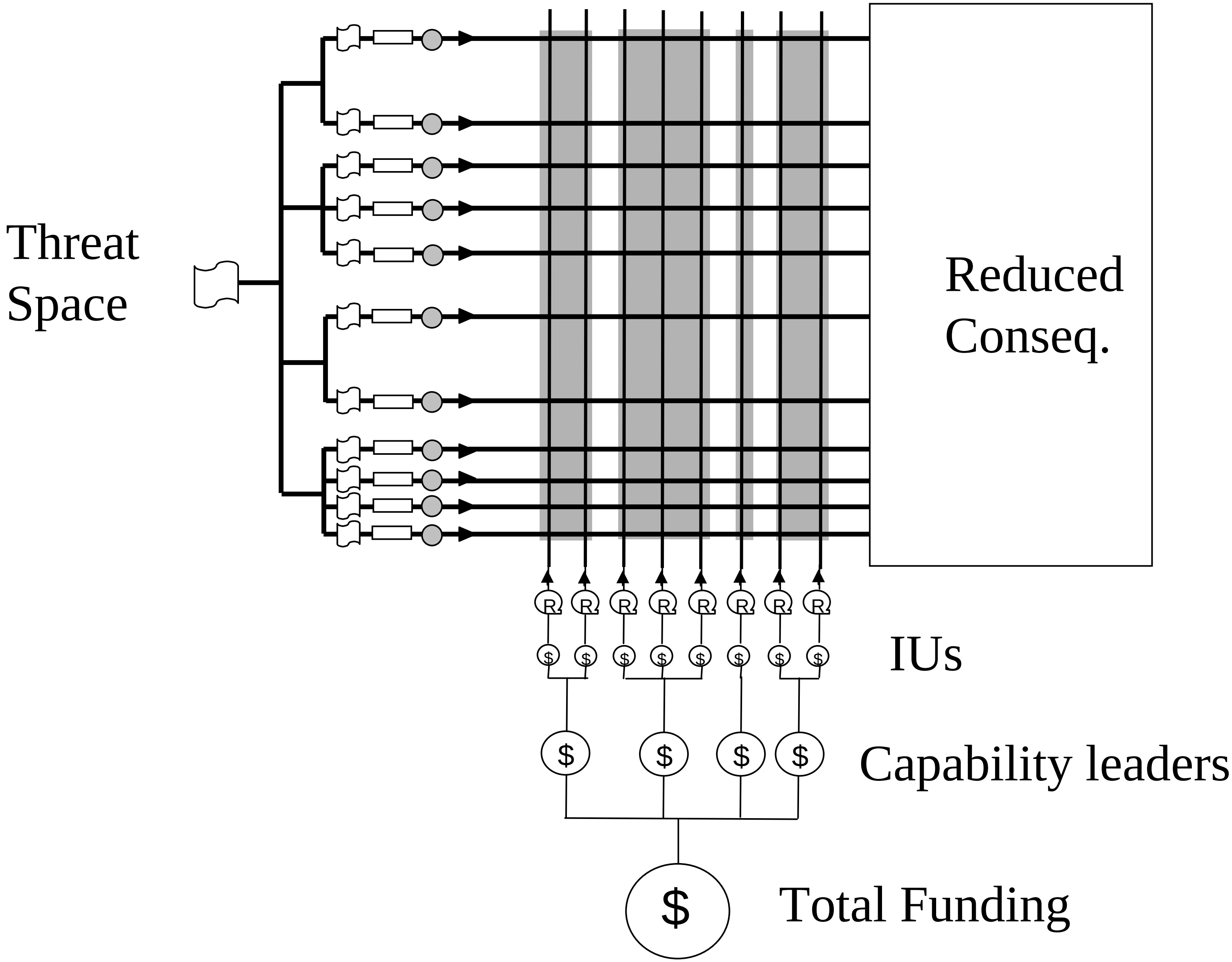


Capability Experts and Setup

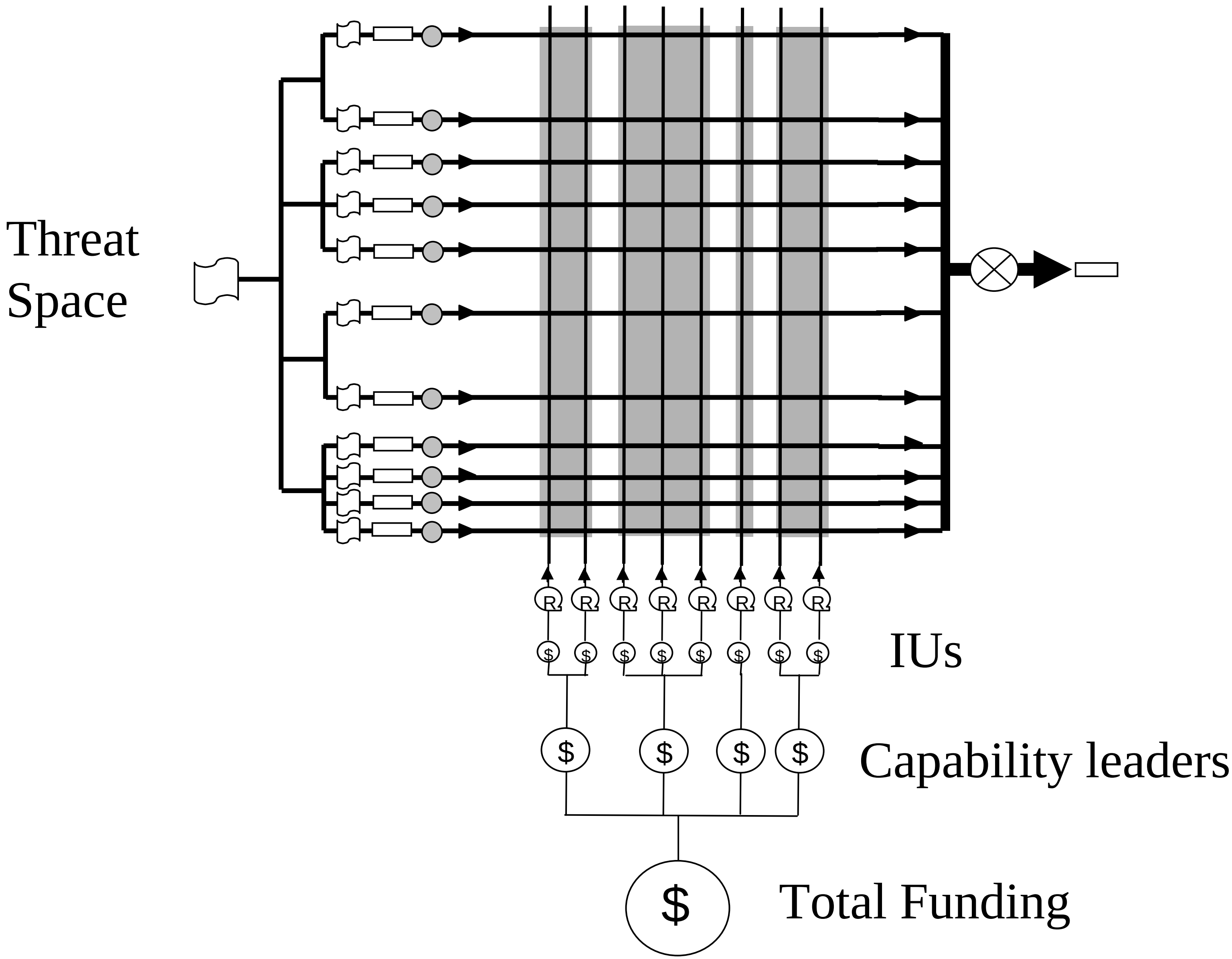


• CB Event Cards
• IU Capability Cards
• Remediation Cards

Models & Analysis



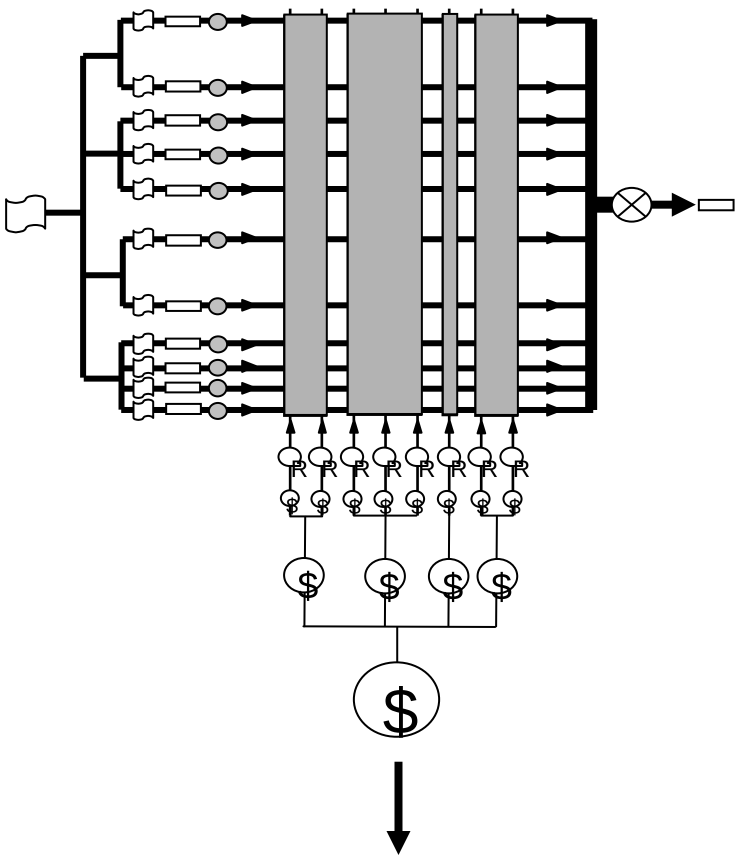
Models & Analysis

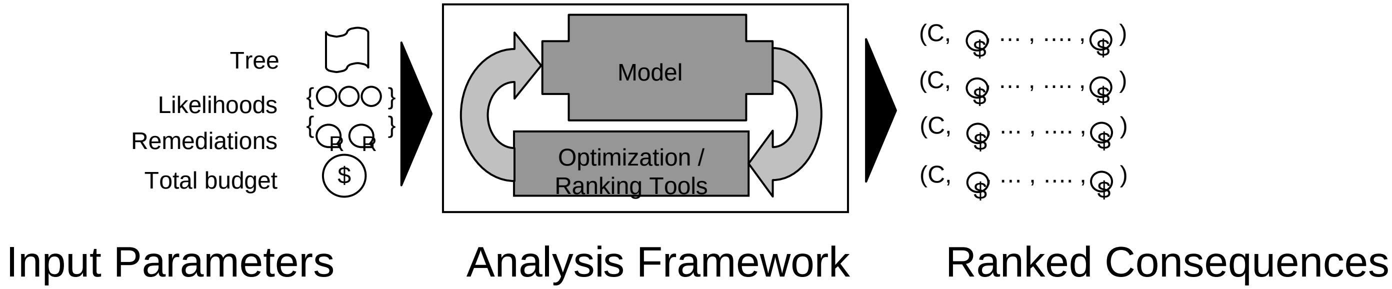


MIDST Analysis Components

- Interpolation
    - Intelligent and Classical Interpolation based on inputs (*Nonlinear interpolation*)
- Data Fusion
    - Fuzzy, probabilistic and other fusion techniques (*Average*)
- Expected consequences
    - Possibility/Probability means of computing expectations (*Likelihood expectation*)
- Optimization and Ranking
    - Multi-objective optimization (*GA*, SA and RM)
    - Rank ordering using fuzzy integrals (*Choquet* and others)
- Sensitivity/Credit analysis
    - Sensitivity of portfolio
    - Credit analysis (scenario exclusion analysis, IU exclusion analysis)

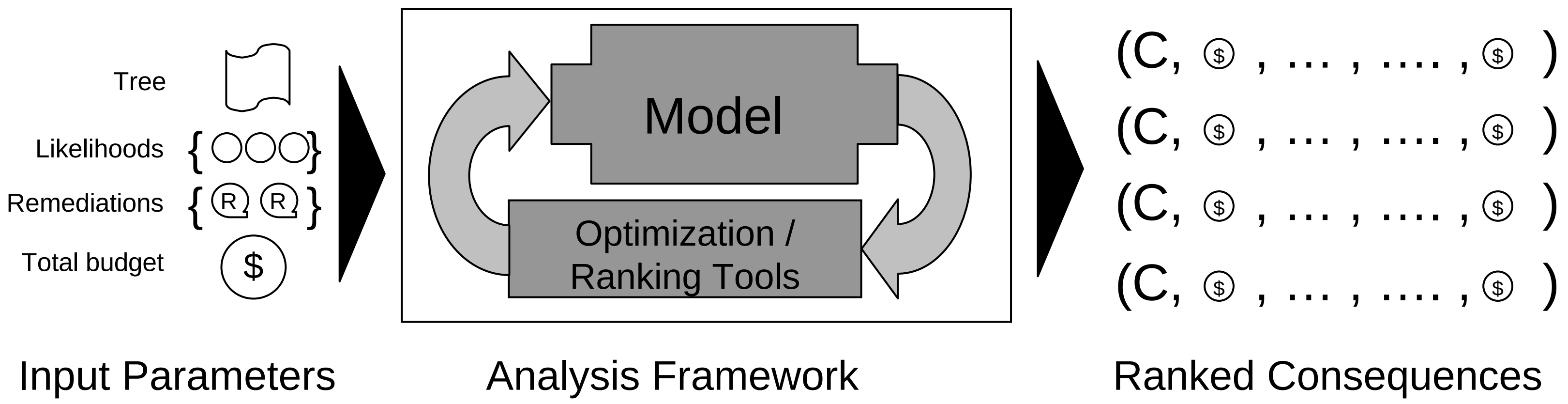
Optimization Loop



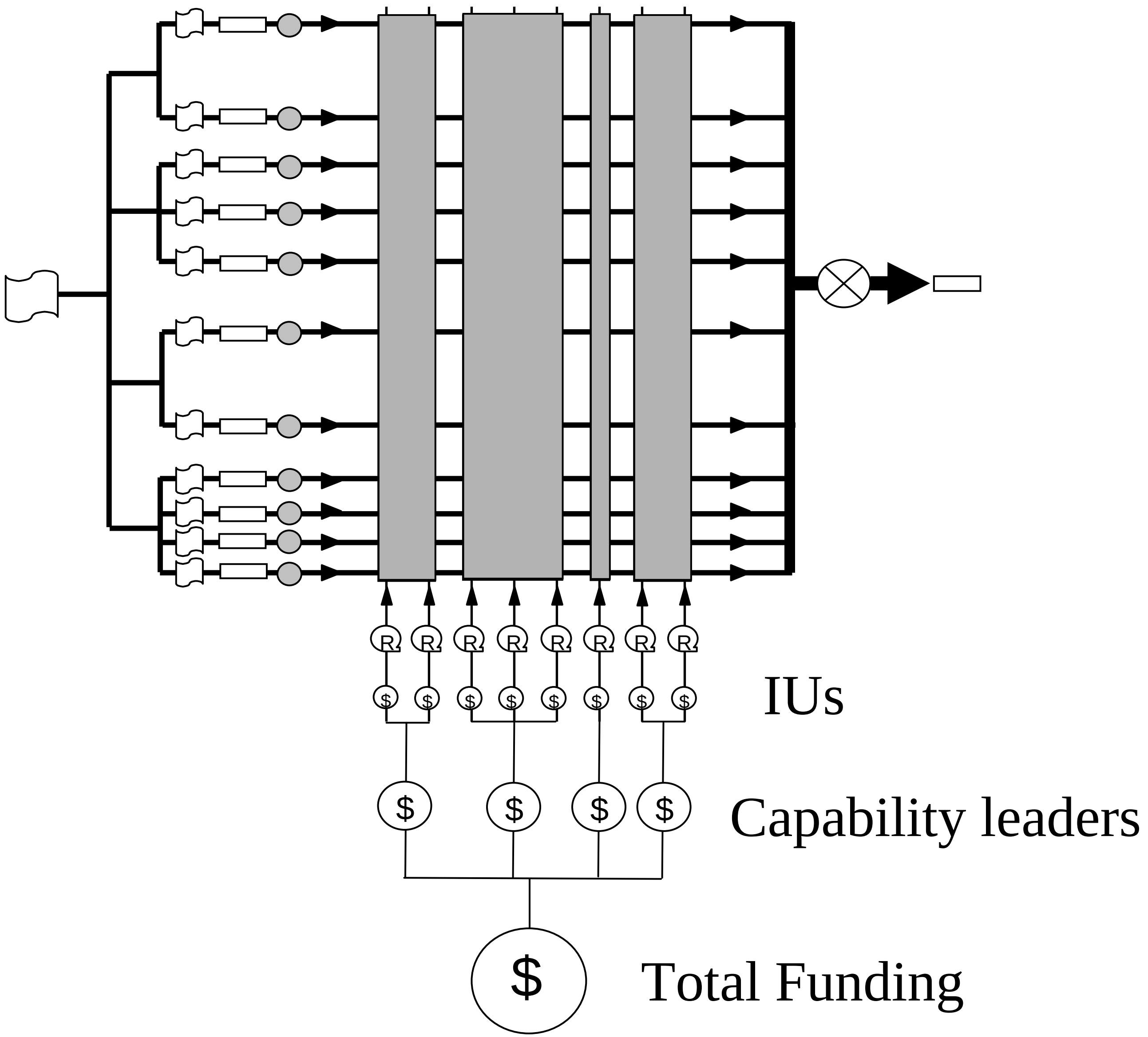


Optimization

Allocation of funds to minimize expected consequences



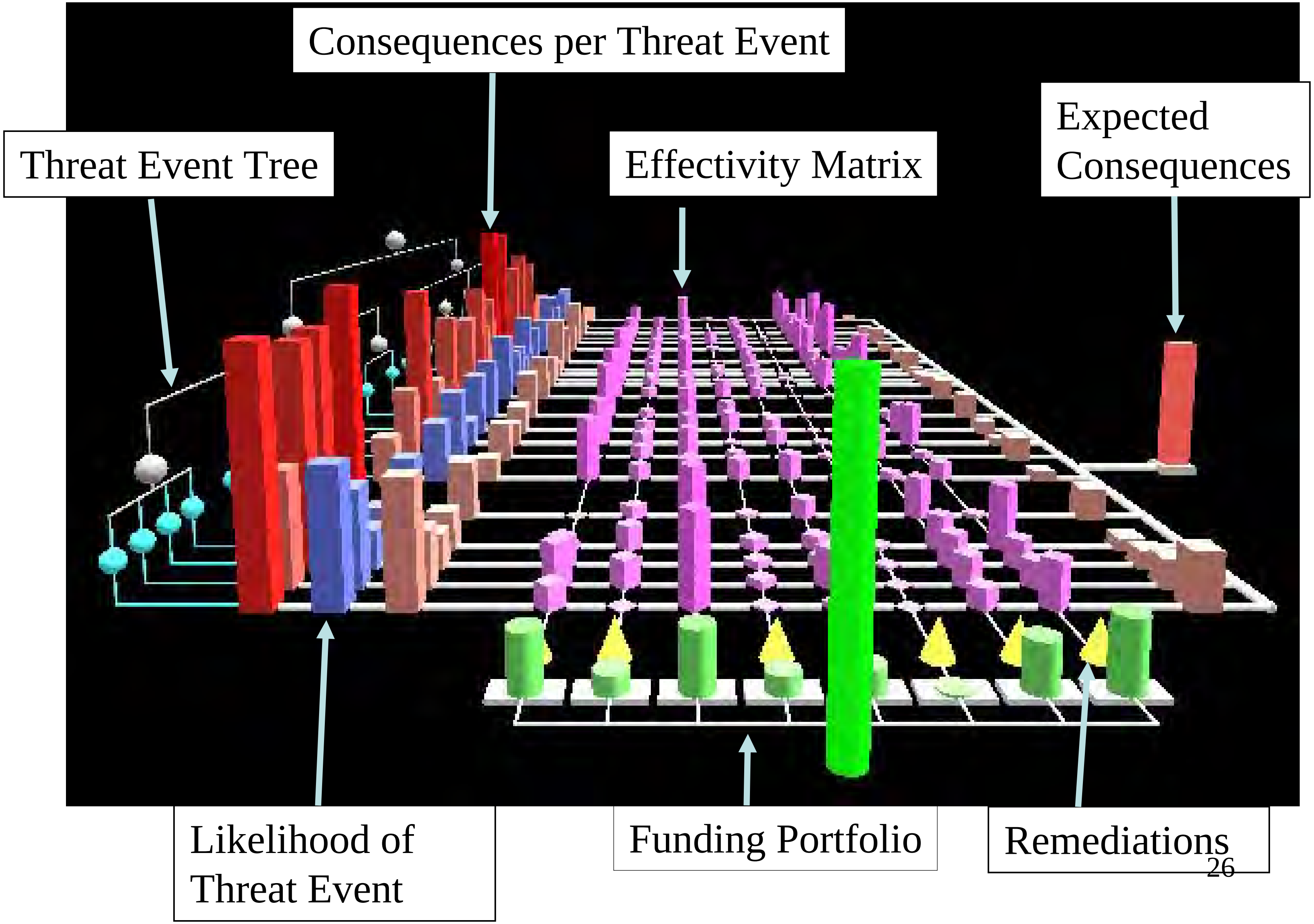
System Architecture



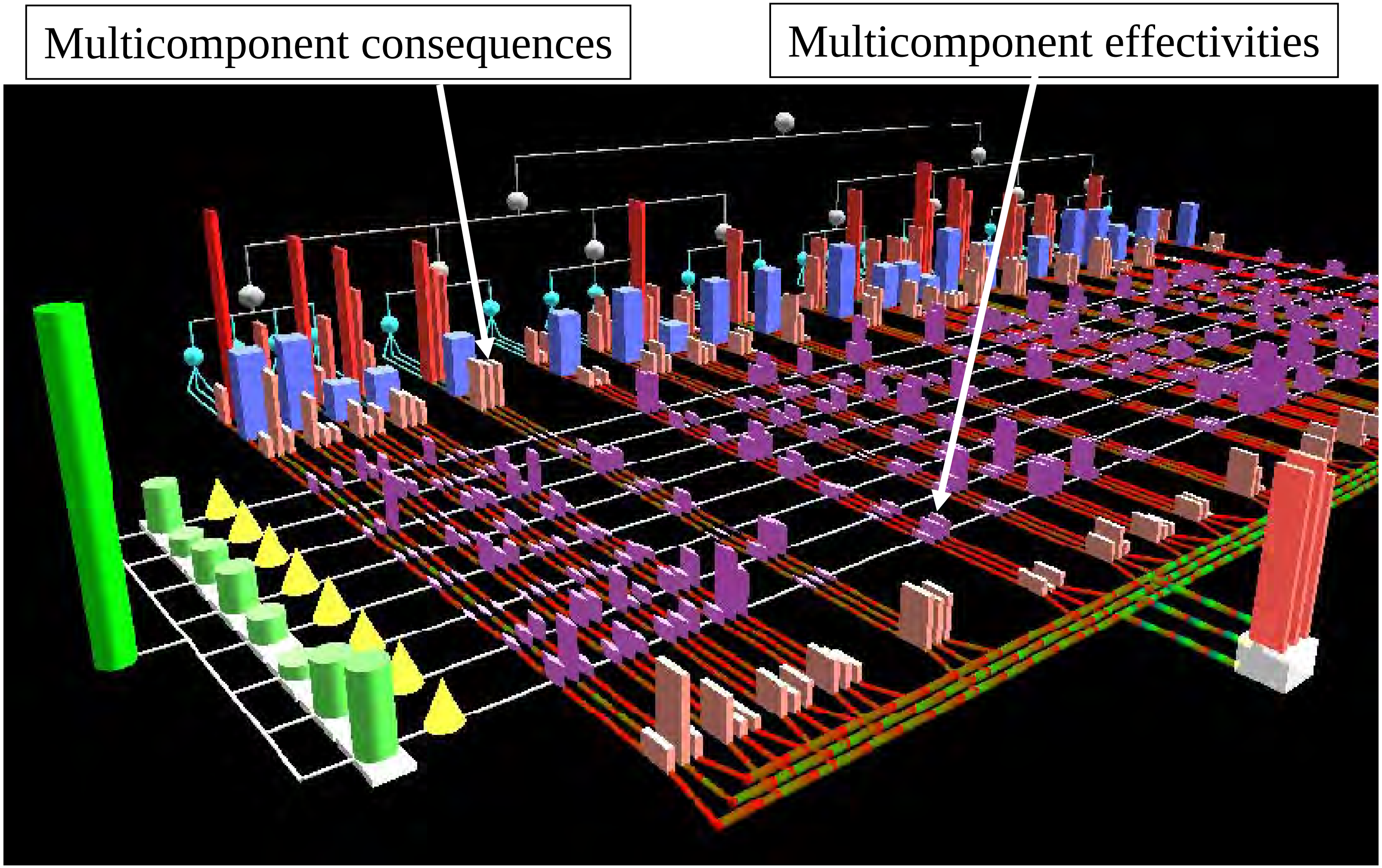
MIDST Visualization Features

- Complete visibility into computational model
- Multi-sensorial approach increases comprehension
- Consequence-flow metaphor
- Real-time user adjustable parameters
- Multi-resolution to manage complexity
- Drill-down for more details
- Animation of calculations and optimization
- Sensitivity and Credit analysis

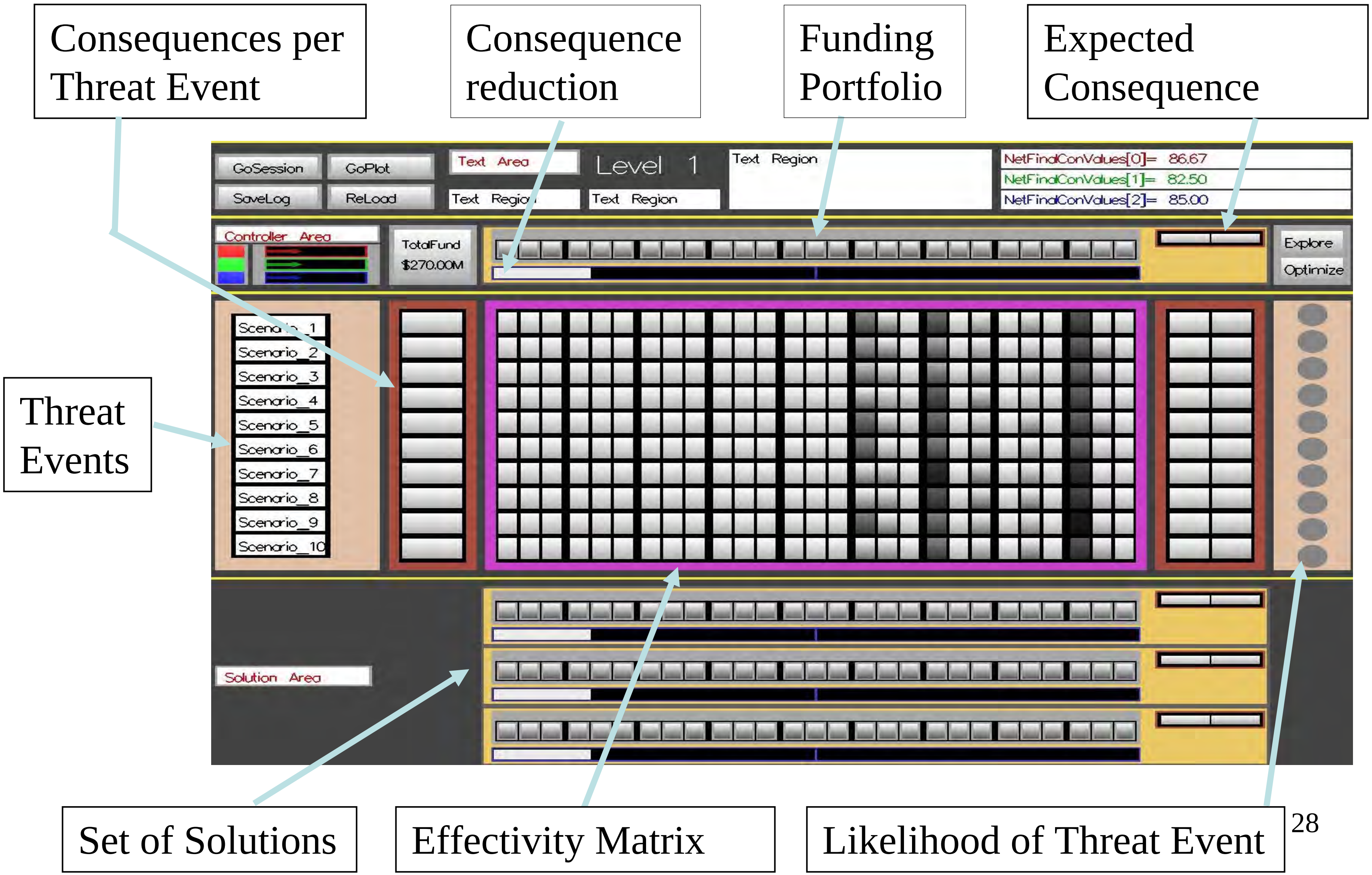
1st Generation Visualization of MIDST



Visualization of MIDST Architecture



2nd Visualization Model of MIDST

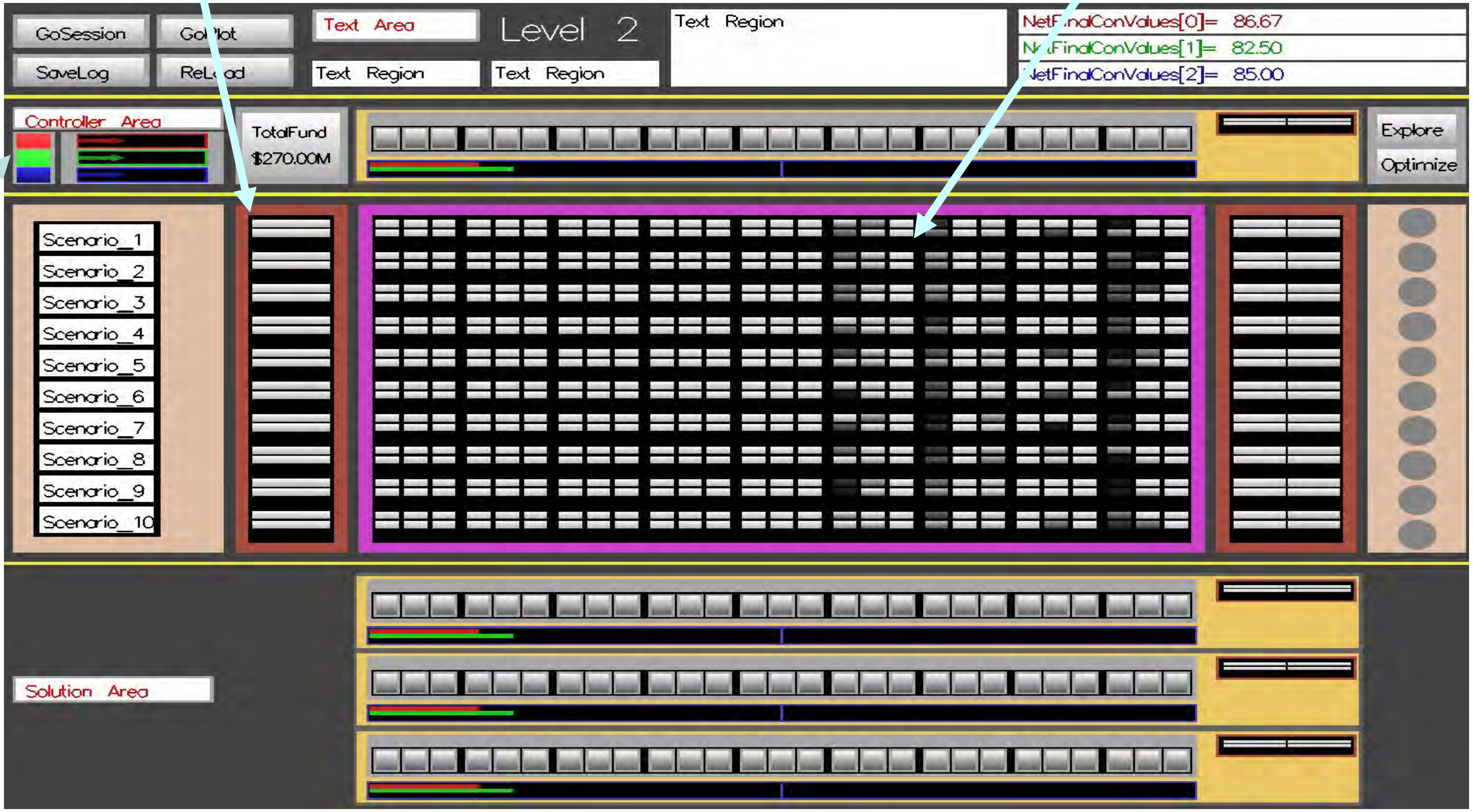


Visualization of MIDST Architecture

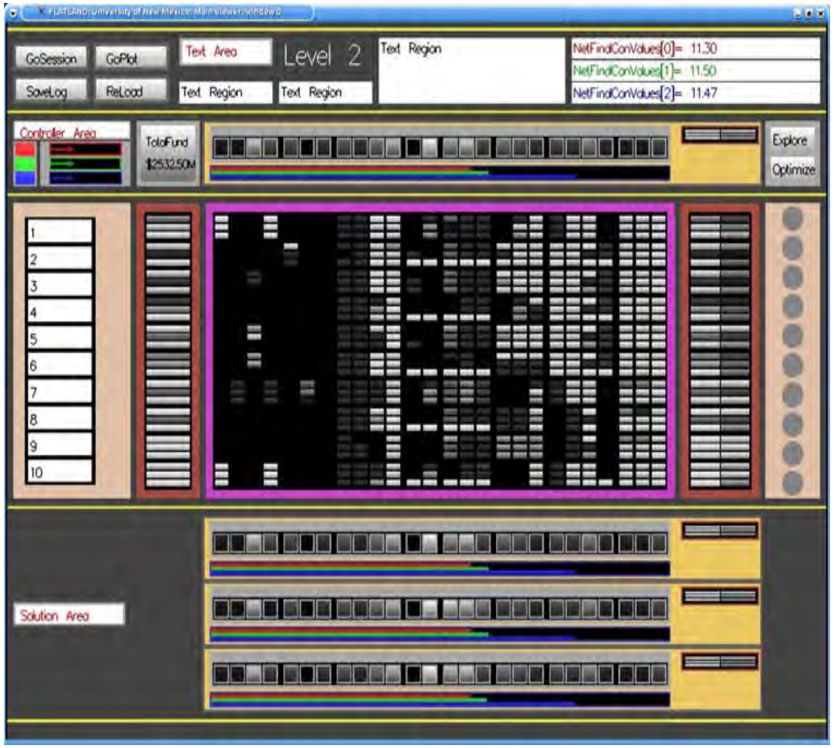
Multi-component consequences

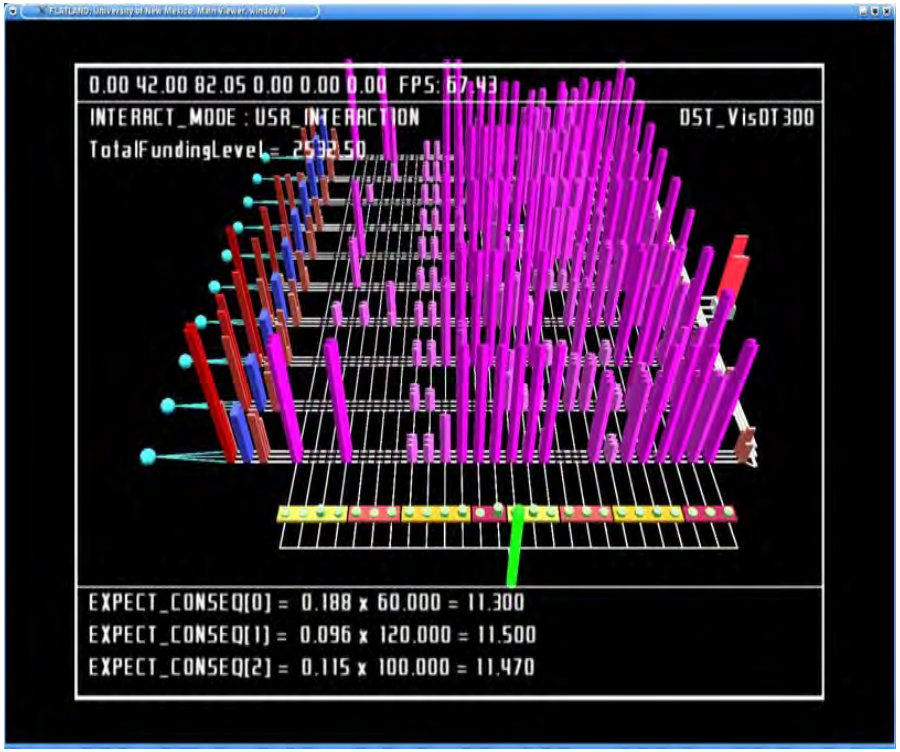
Multi-component effectiveness

Component buttons



Visualization with real data





2D version

3D version

Conclusions

- MIDST that meets the Goals
  - Analytic and algorithmic framework
  - Feasible system architecture
  - Exercises utilizing MIDST analysis
- MIDST further refinement
  - Music and sound
  - Transition between 2D and 3D versions.
  - More drill-down details.

Acknowledgements

- DTRA University Strategic Partnership
- UNM Professors T. Ross and M. Taha
- NMSU Professors H. Nguyen and R. Prasad
- Drs. T. Bott and S. W. Eisenhawer

Thank you !

Optimal Networks for Siting Bio-Samplers in Buildings

Michael D. Sohn, David Lorenzetti,

Indoor Environment Department

Lawrence Berkeley National Laboratory

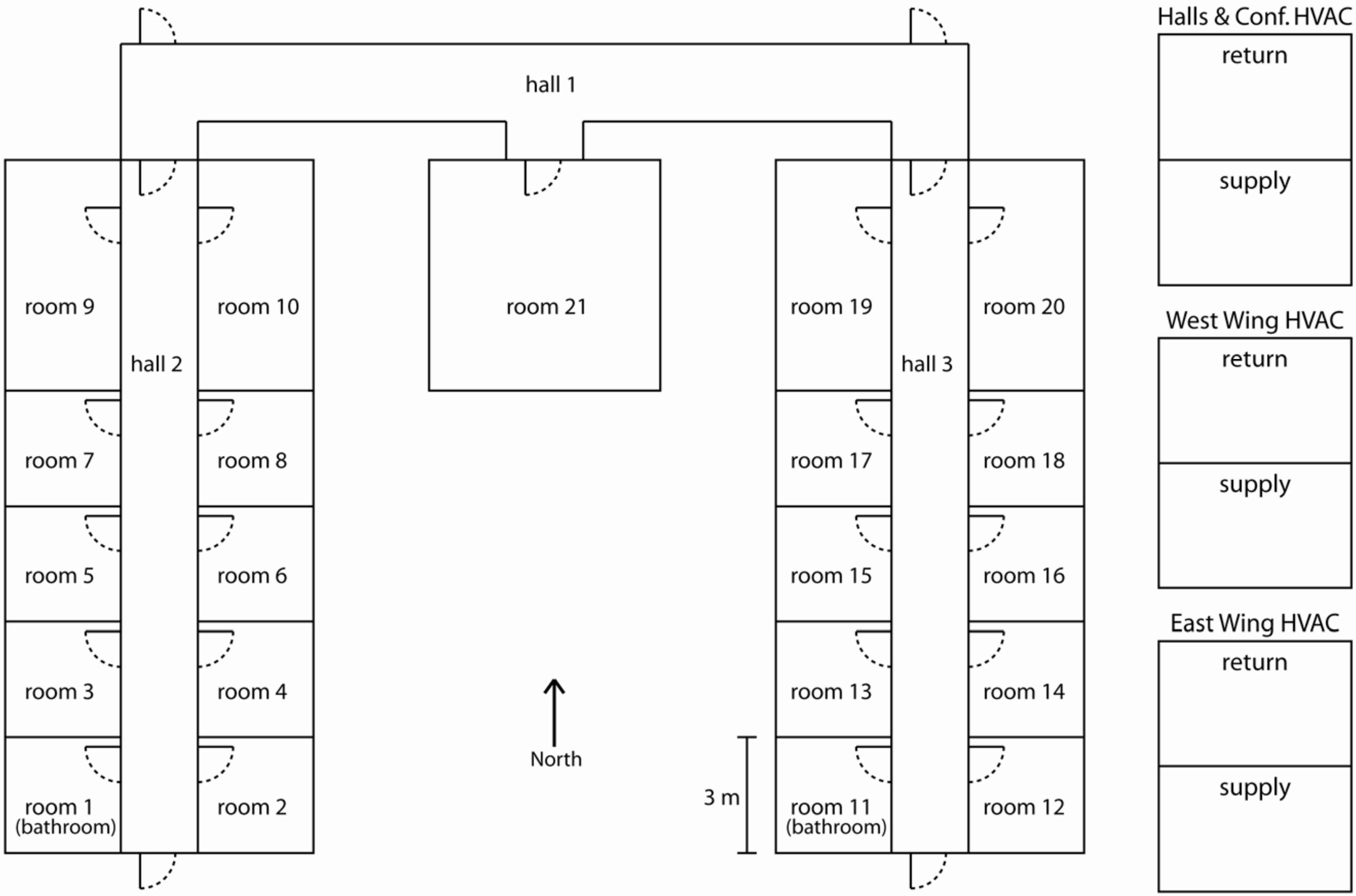
Presentation at Chemical Biological Information Systems Conference, January 2007, Austin, TX

This work was supported in part by the Office of Chemical Biological Countermeasures, of the Science and Technology Directorate of the Department of Homeland Security and performed under U.S. Department of Energy Contract No. DE-AC03-76SF00098.

Objectives and Goals of Monitoring System

- Where do you place samplers in complex buildings to maximize the probability of detecting a biological event?
- How do you account for uncertainties that might affect sampler network performance? Uncertainties include:
  - release conditions (e.g, locations, amounts, durations)
  - building and environmental conditions (e.g, HVAC operation, meteorology)
  - model parameters
  - sampler performance characteristics (e.g, effect of fouling on filter)
- How do you identify "blind spots" (difficult-to-monitor locations)?

Application to 33-Room Building



Probability of Detecting an Event

Probability(network detection) =

P(detector 1 = on, detector 2 = off) +
P(detector 1 = off, detector 2 = on) +
P(detector 1 = on, detector 2 = on)

= 1 - P(network not detecting release)

Overview of Siting Algorithm

1. Develop "event tree" identifying all uncertain variables and their probability distributions

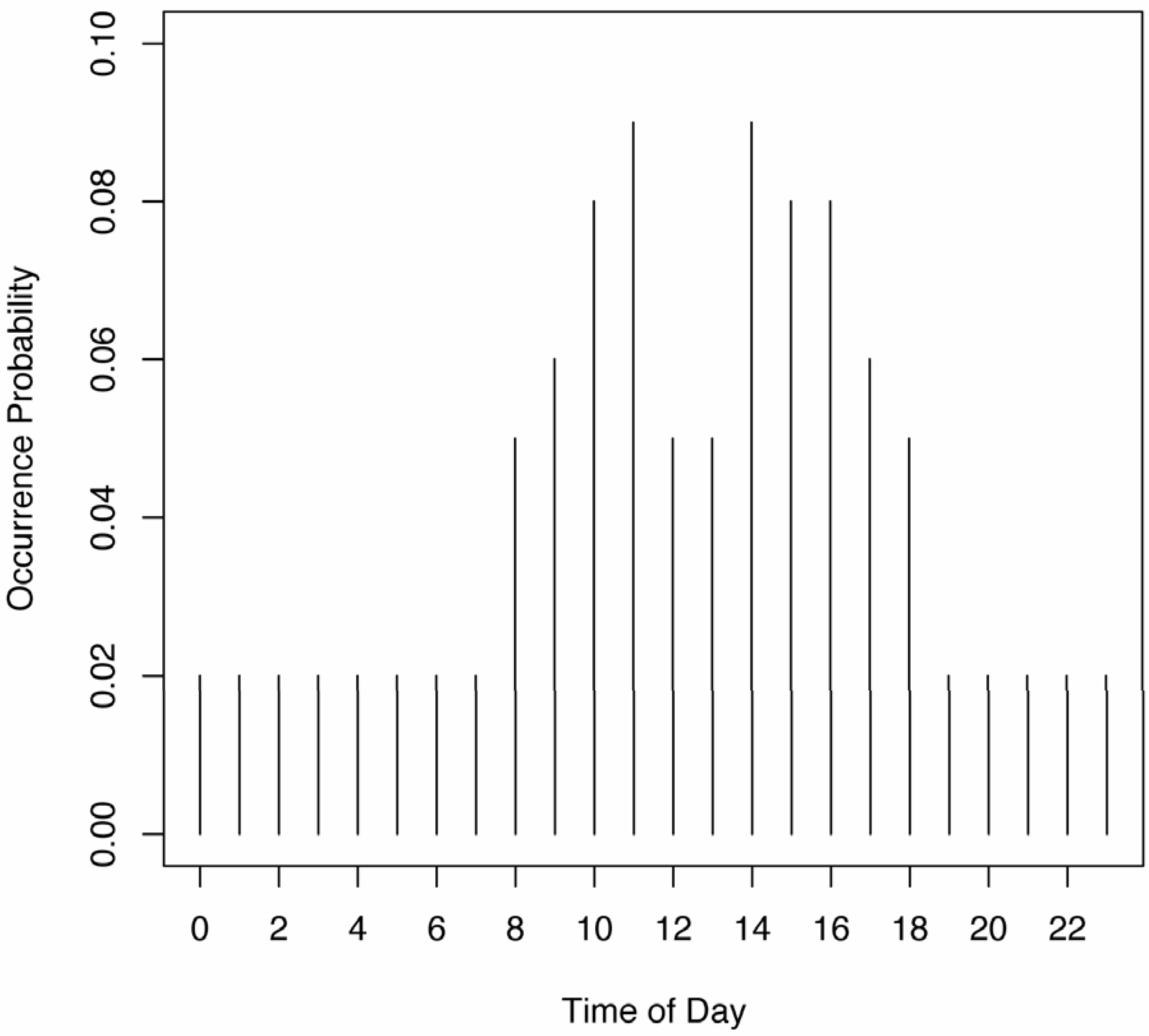
2. Predict airflow and agent dispersion
   - for each scenario
   - at all candidate sampler locations

3. Estimate probability that a hypothetical sampler will detect each scenario

4. Choose sampler locations
   - maximize probability that the network will detect an unknown release
   - account for event occurrence and sampler detection probabilities

(Sohn, MD and Lorenzetti, DM (2007). Siting Bio-Samplers in Buildings. *Risk Analysis*, accepted)

Release Time Probabilities

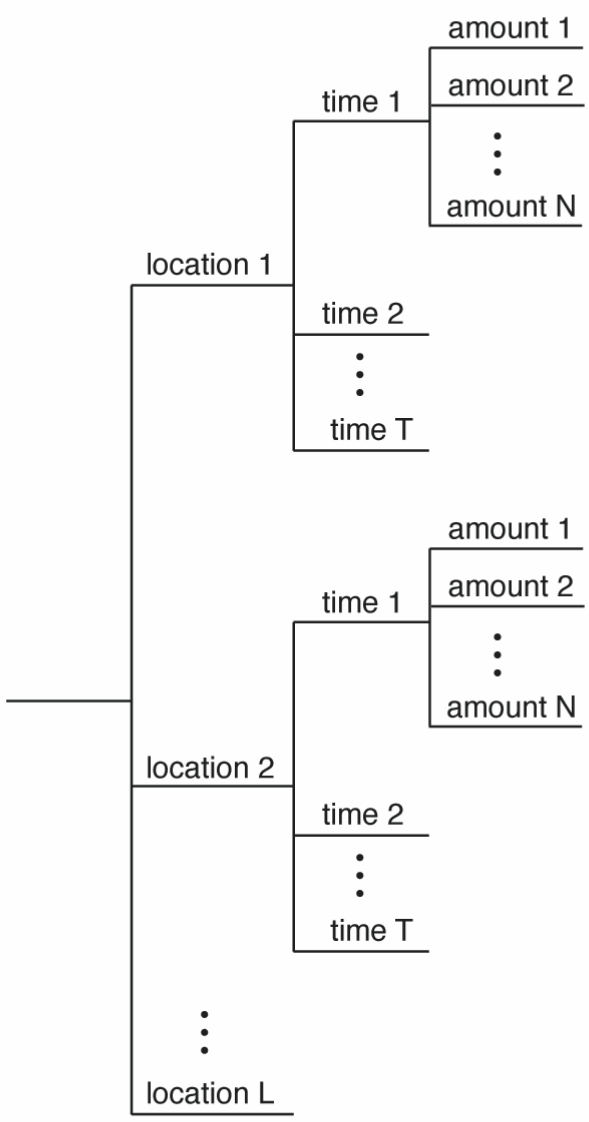


Release Mass and Location Probabilities

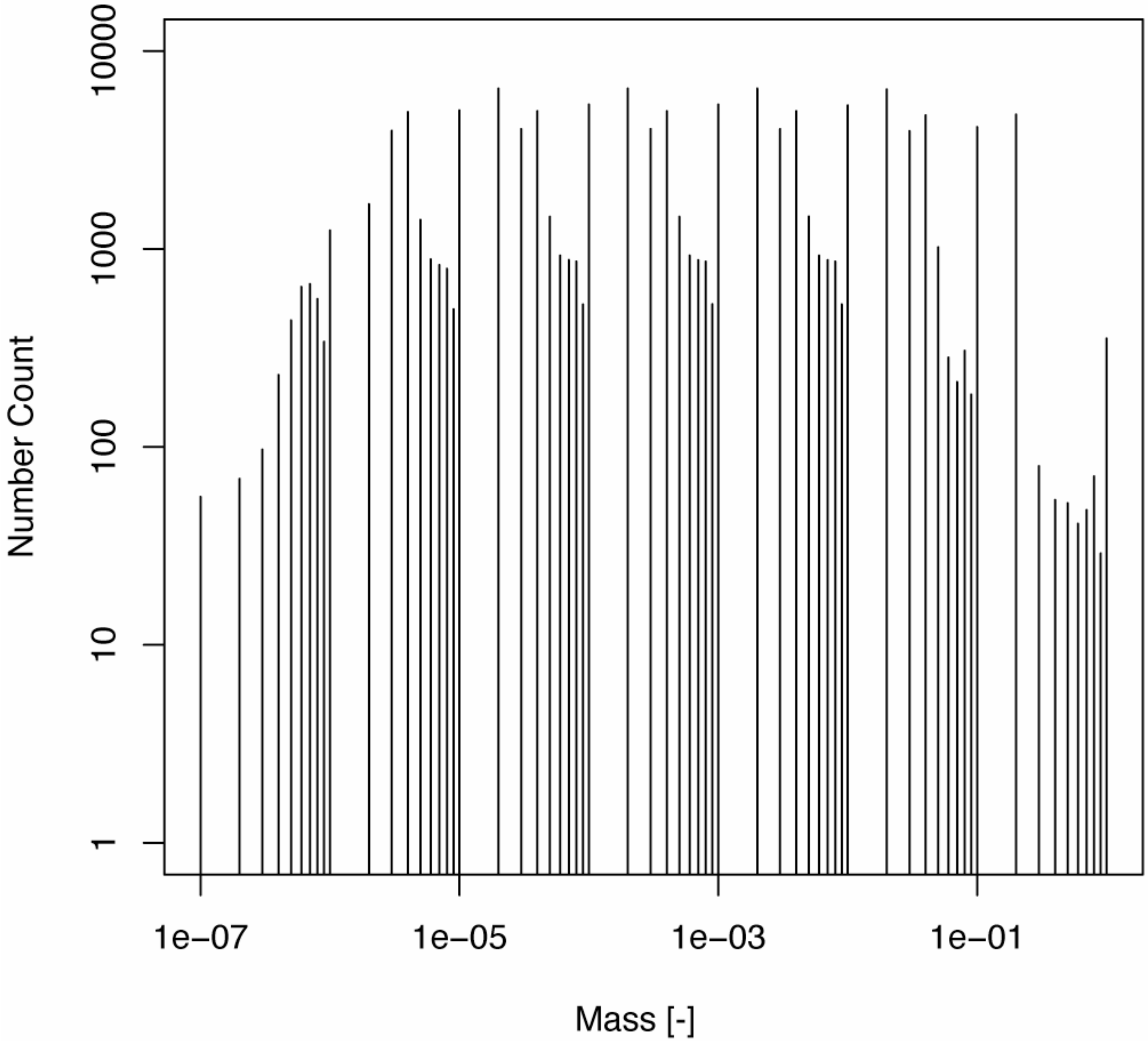
Mass [gram]	Probability
0.001	5%
0.005	5%
0.01	10%
0.05	20%
0.1	20%
0.5	10%
1	10%
5	10%
10	5%
50	5%

Location	Probability	Number Count
Hallways	3%	3
Conf. Room	2%	1
Offices	1%	20
HVAC Supply	8%	3
HVAC Return	10%	3
Ceiling Plenum	5%	3

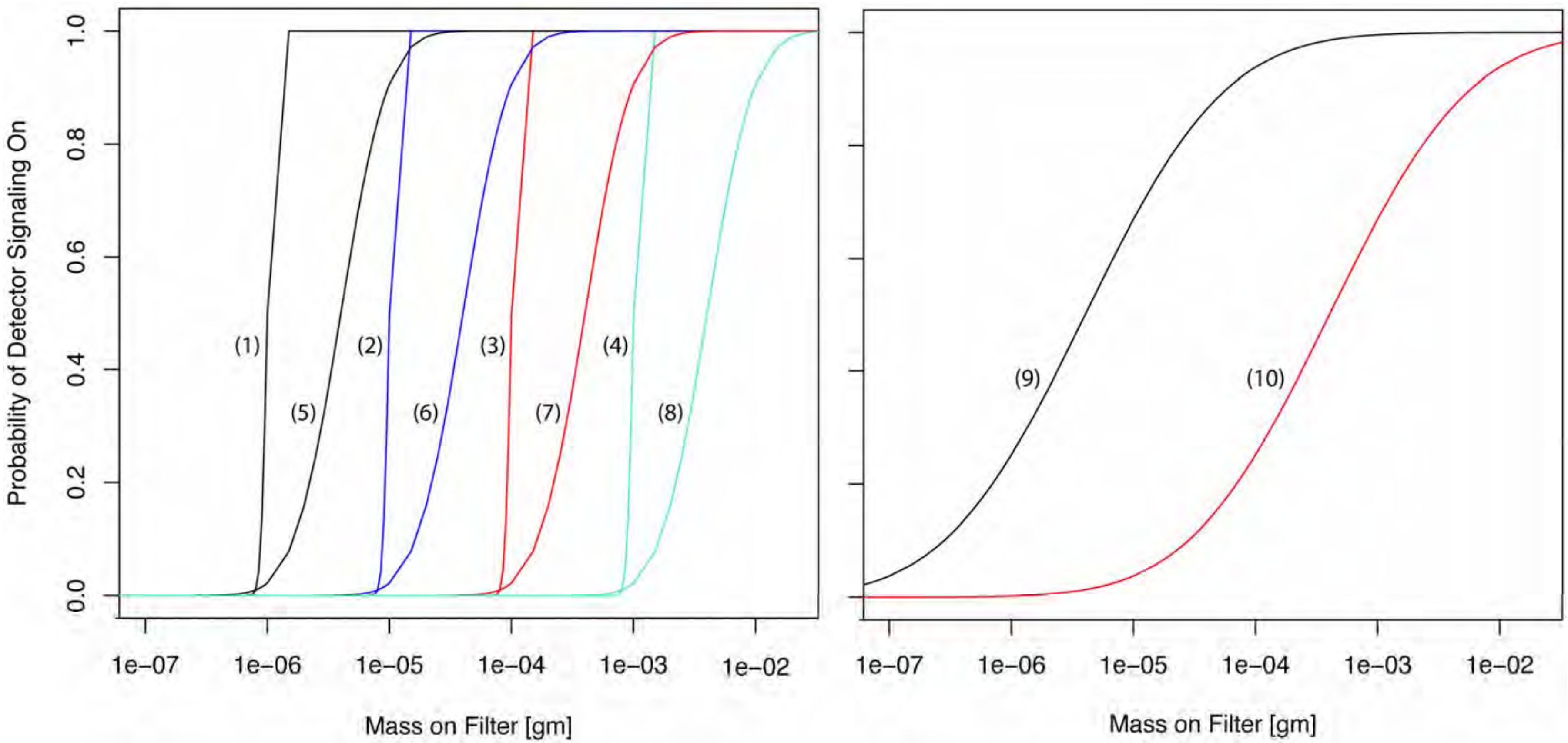
Event Tree


amount 1
amount 2
amount N
time 1
location 1
time 2
time T
amount 1
amount 2
amount N
time 1
location 2
time 2
time T
location L

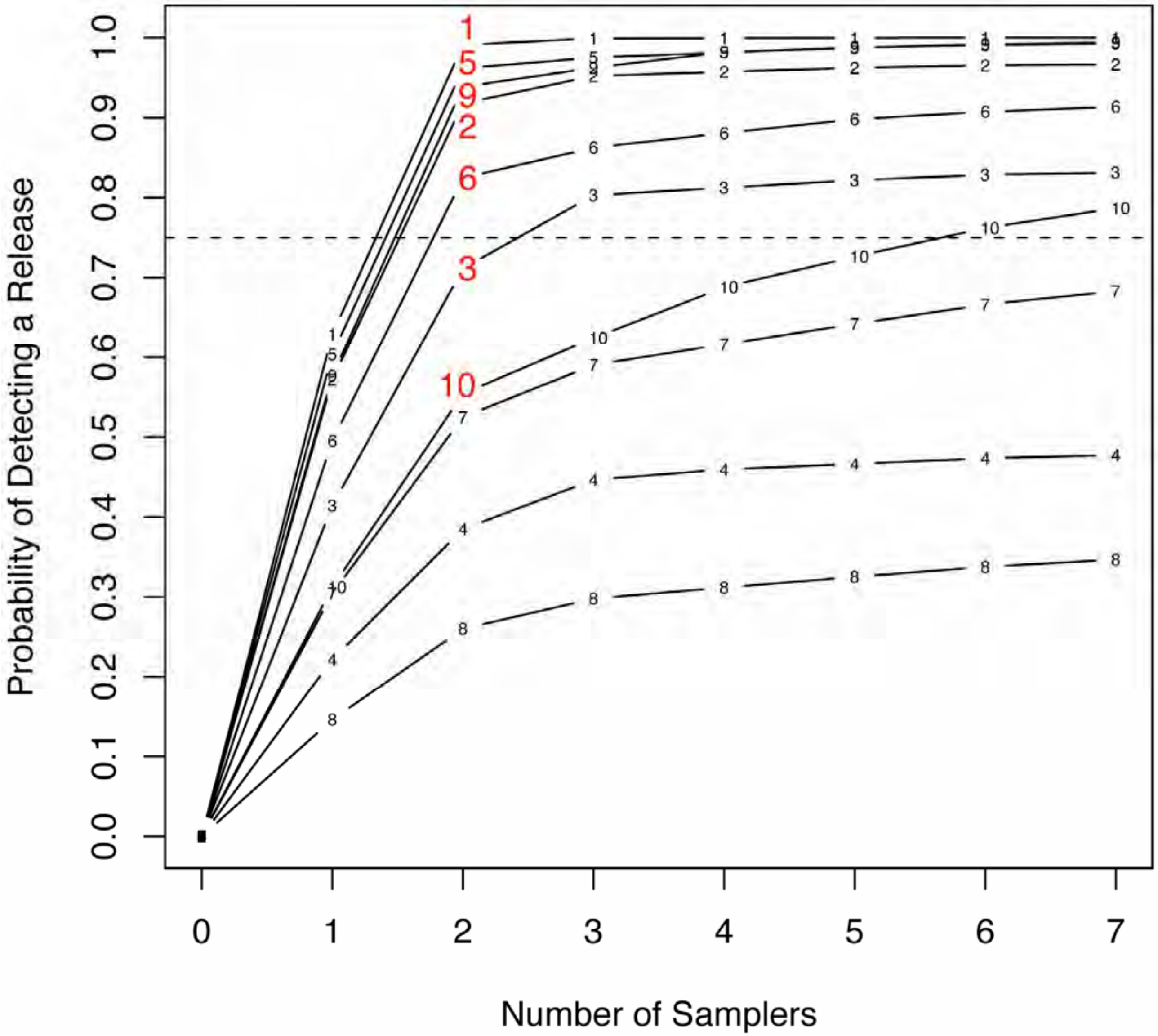
Mass Predicted on Filters



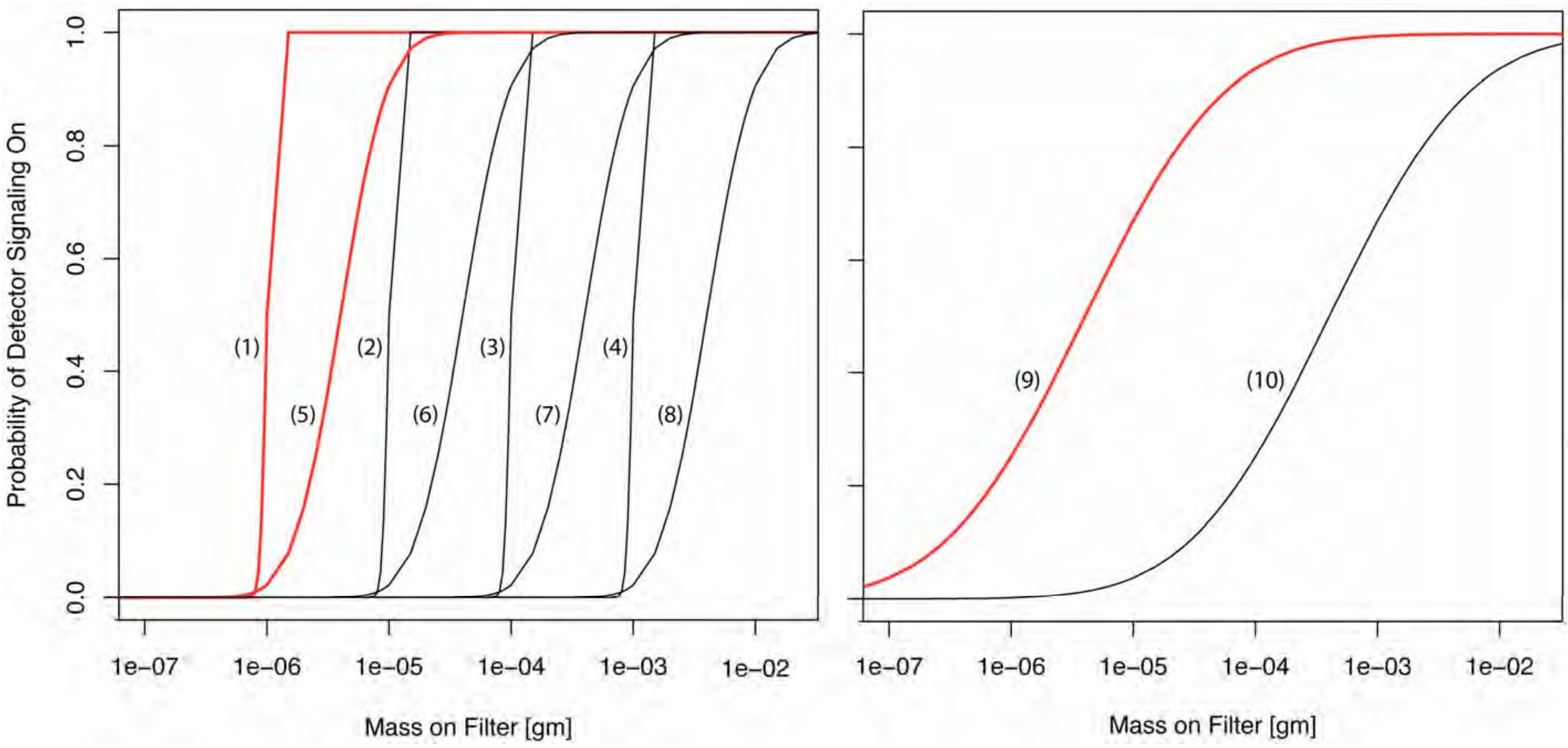
Sampler Performance Curves



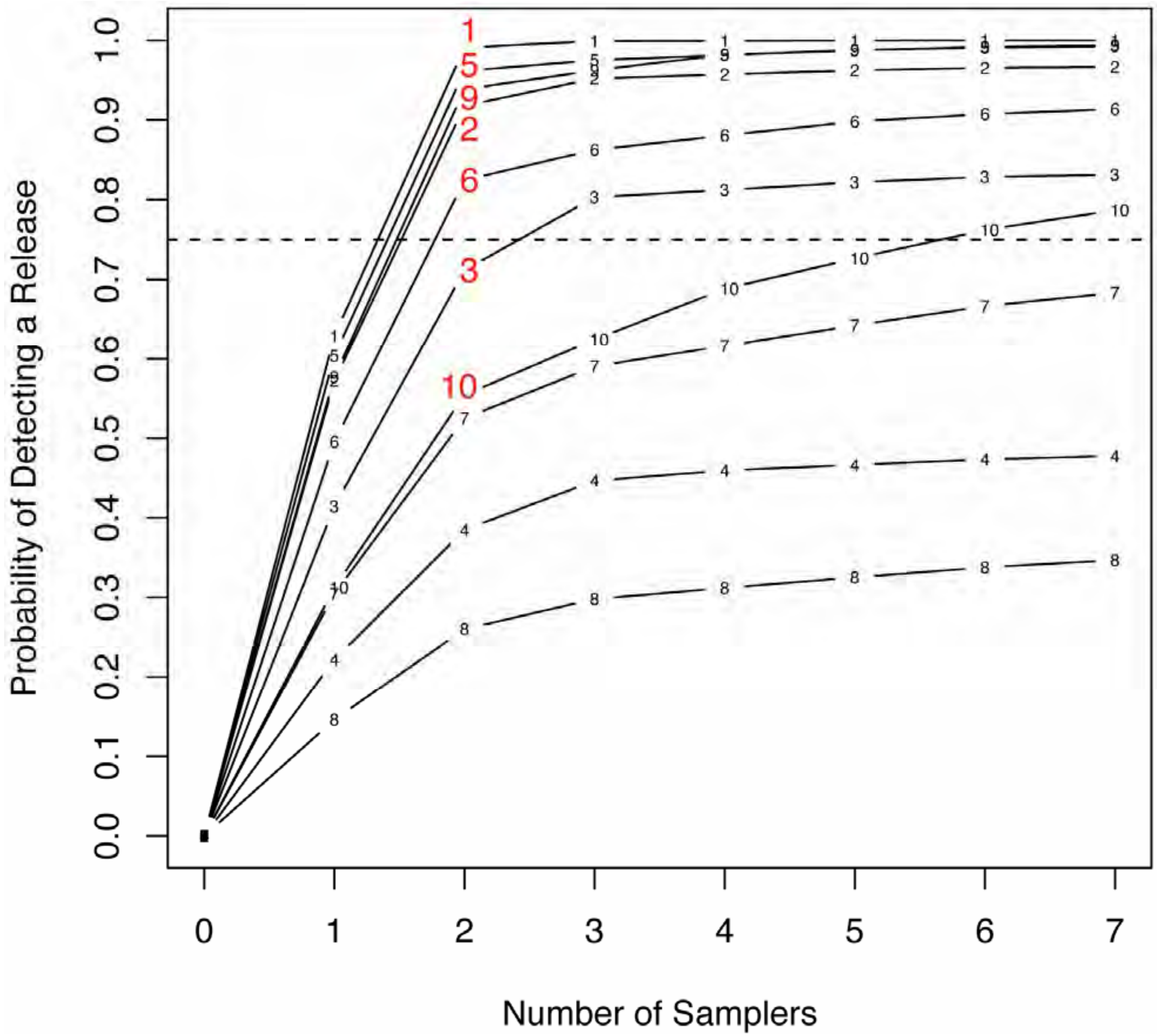
Probability of Network Detecting Release



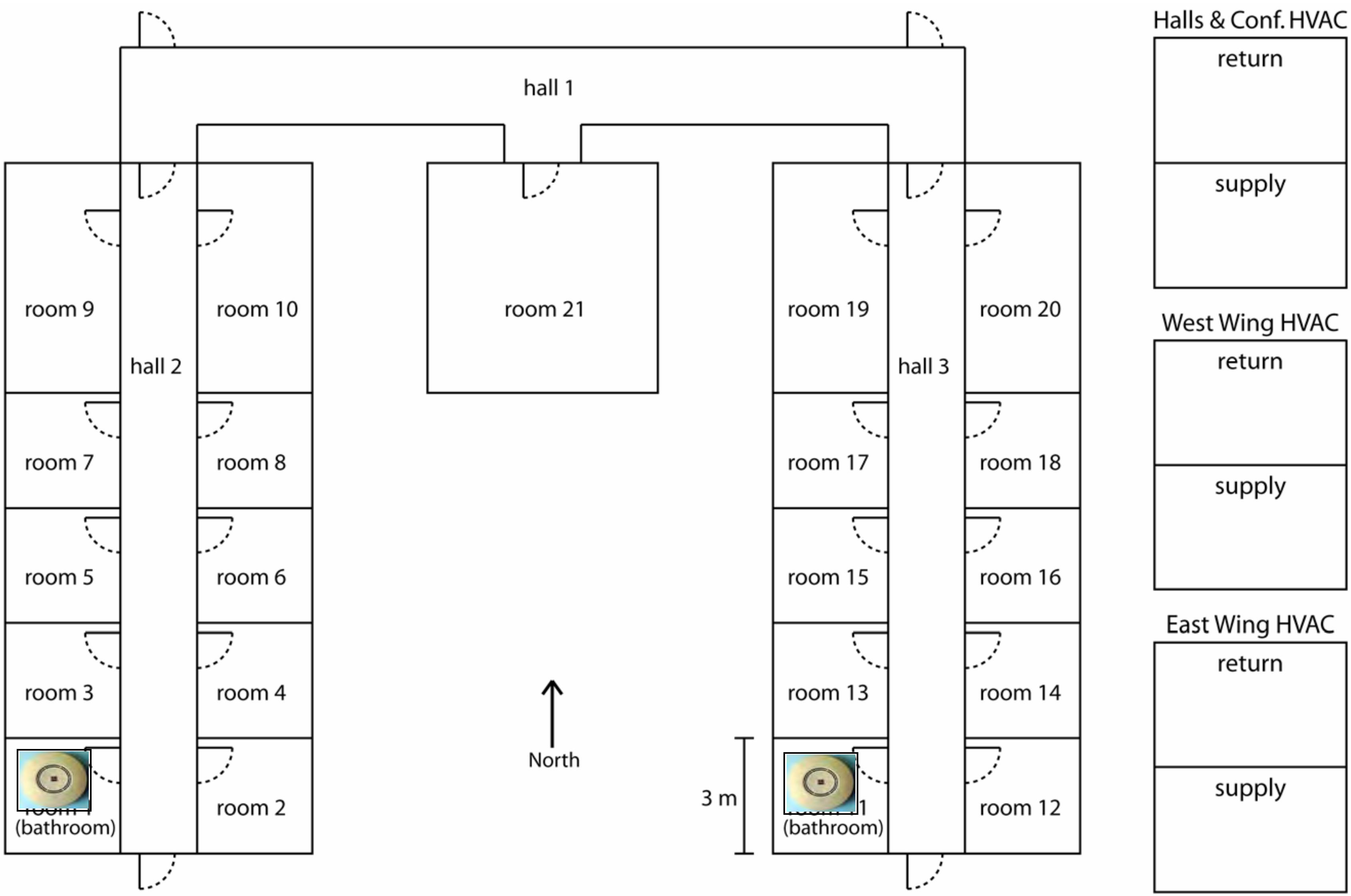
Sampler Performance Curves



Probability of Network Detecting Release



Optimal Placement of 2 Samplers



Minimum Number of Samplers Needed for at Least 75% Probability of Detection

Curve	Optimal Sampler Locations
1	Room 1, Room 11
5	Room 1, Room 11
9	Room 1, Room 11
2	Room 1, Room 11
6	Return (East), Return (West)
3	Return (East), Return (West), Return (North)
10	Return (East), Return (East) Return (West), Return (West) Room 1, Room 11

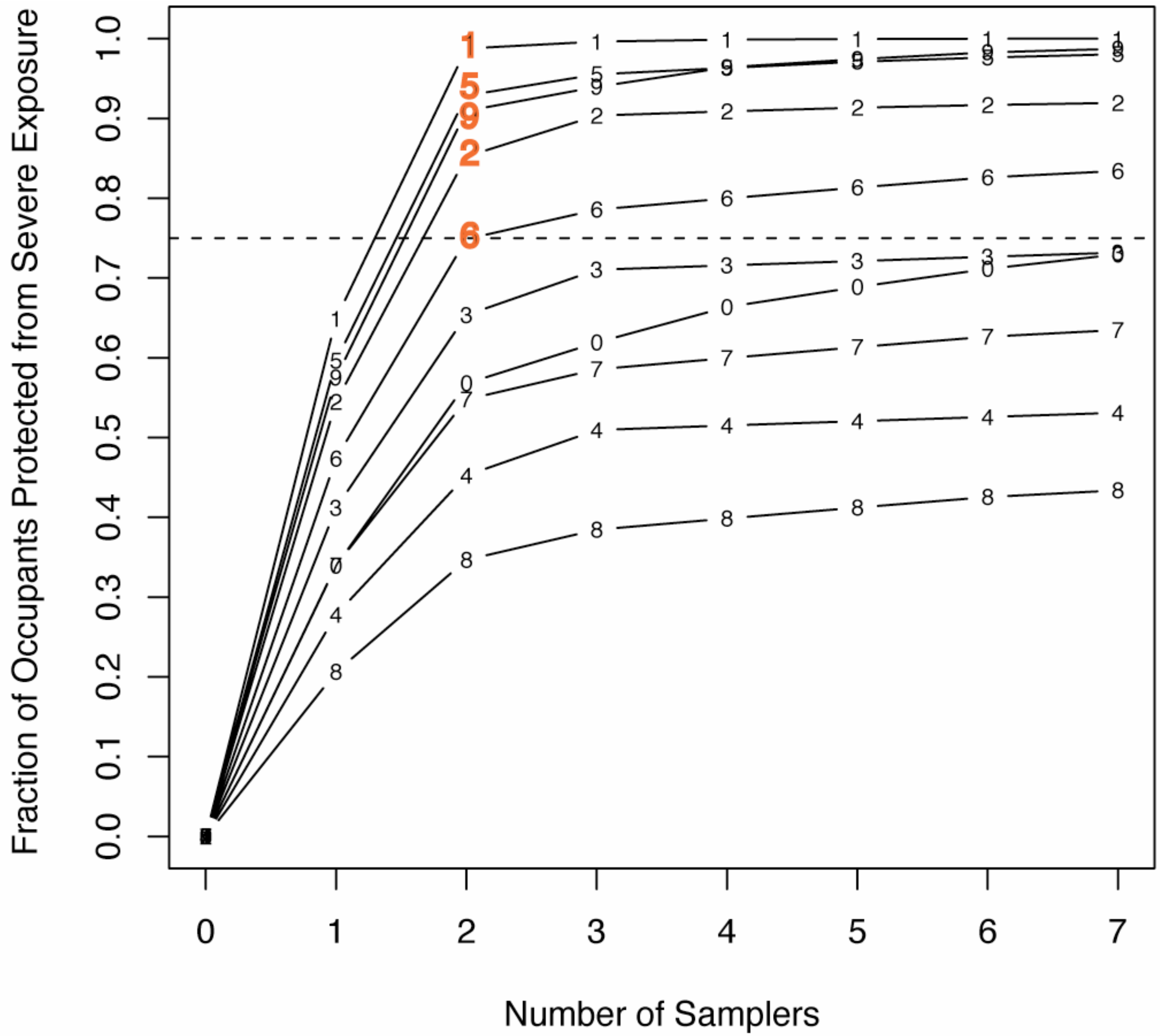
Minimize Casualties Due to an Undetected Attack

- If an attack is detected, health care can be provided. Otherwise, an undetected leads to casualties.

- Select optimal sampler placements that minimize the expected number of casualties due to an undetected attack.

- Requires statistical estimates of occupancy and toxicity of agent.

Fraction of Occupants Protected from Severe Exposure



Minimum Number of Samplers Needed for at Least 75% Protection

Curve	Optimal Sampler Locations
1	Hall (East), Hall (West)
5	Return (East), Return (West)
9	Return (East), Return (West)
2	Return (East), Return (West)
6	Return (East), Return (West) Conference Room

Summary and Concluding Remarks

- Optimal placement of samplers requires a probabilistic algorithm to:
  - account for uncertainties in event scenarios
  - estimate probability that a candidate network will detect scenarios

- Approach can compare sampler characteristics:
  - investigate tradeoff between cost and quality of samplers
  - investigate combinations of sensor and sampler types

- Illustrative application shows:
  - optimal locations may be not be obvious
  - detection sensitivity may be more important than certainty
  - efficient software implementation important

Sensor Networks for Indoor Sensor Data Fusion

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Ashok J. Gadgil[2], William W. Nazaroff[1,2]

[1]Lawrence Berkeley National Laboratory
[2]University of California, Berkeley

Presentation at Chemical Biological Information Systems Conference, January 2007, Austin, TX

This work was supported in part by the Office of Chemical Biological Countermeasures, of the Science and Technology Directorate of the Department of Homeland Security and performed under U.S. Department of Energy Contract No. DE-AC03-76SF00098.

Why is Sensor Data Fusion in Buildings Important?

- People spend 90% of their time indoors
- Buildings are both direct and indirect targets
- Long residence time may result in many people exposed to agent
- Buildings can protect people
  - active protection (filters, zoning for isolation, ventilation)
  - passive protection (settling, sorption)

Operational Objectives of an Indoor SDF System

- Detect:
  - — confirm an attack has occurred
- Characterize event:
  - — locate and characterize sources
  - — identify contaminated areas in building
  - — predict future migration of agent through building
  - — identify safe zones, evacuation routes

- Assess hazards:
  - — predict exposures and casualties
- Respond:
  - — is information “actionable”?
  - — what is the response sequence?

Factors Complicating SDF and Decision Analysis

- Problem is inherently probabilistic and uncertain
  - — release conditions are unknown
  - — models are imperfect and potentially error-prone
  - — data may contain false positives/negatives

- Decisions are time-critical. Consequences exist for:
  - — responding too quickly to uncertain information
  - — delaying response until more information is available

- Monitoring is costly
  - — limited supply of hardware
  - — sensor hardware must be operated and maintained

Steps toward SDF and Sampler Siting

- Develop algorithm that accounts for uncertainties in:
  - release conditions (e.g, locations, amounts, durations)
  - dispersion drivers (e.g, HVAC operation, meteorology)
  - model parameters
  - sensor performance characteristics (e.g, effects of fouling on filters)

- Code software package that integrates:
  - fate and transport modeling
  - statistical inference techniques, and
  - optimization algorithms

- Test algorithm against data from real and synthetic experiments

- Refine algorithm and develop user-friendly software

Bayes Monte Carlo Formulation for Real-Time SDF

$$p(Y_k|O) = \frac{L(O|Y_k)p(Y_k)}{\sum_{i=1}^{K} L(O|Y_i)p(Y_i)} \quad (1)$$

- $p(Y_k|O)$ is the posterior probability of the k^{th} Monte Carlo simulation for prediction Y_k given the sensor measurements O;
- $L(O|Y_k)$ is the likelihood of observing measurements O given model prediction Y_k;
- $p(Y_k)$ is the prior probability of the k^{th} Monte Carlo simulation;
- N is the number of Monte Carlo simulations.

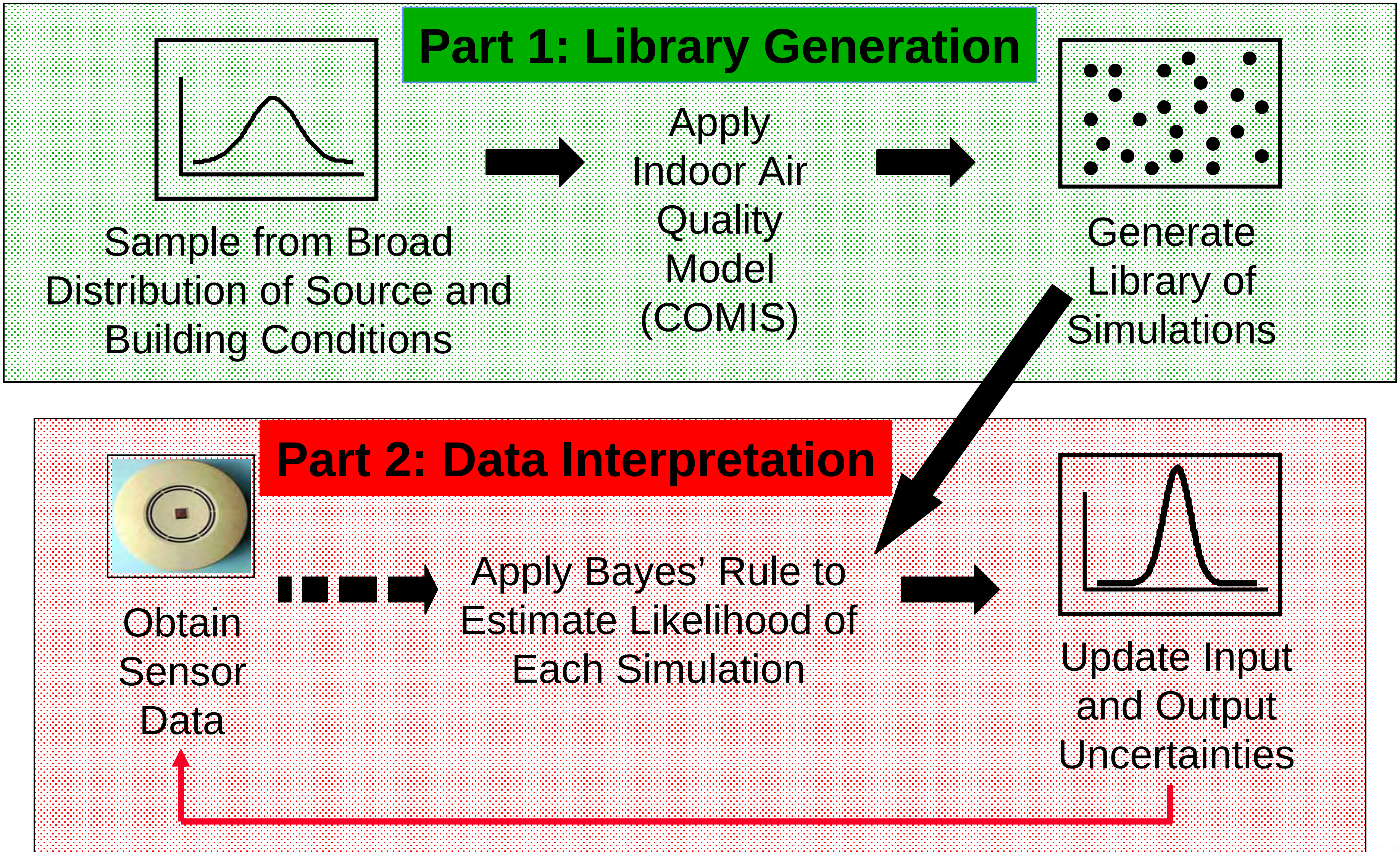
$$\mu'_V = \sum_{i=1}^{K} V_i \cdot p(Y_i|O) \quad (2)$$

$$\sigma'^2_V = \sum_{i=1}^{K} (V_i - \mu'_V)^2 \cdot p(Y_i|O) \quad (3)$$

- V and W represent any model input or output.

BASSET

(Berkeley Algorithm for Sensor System Engineering and Testing)



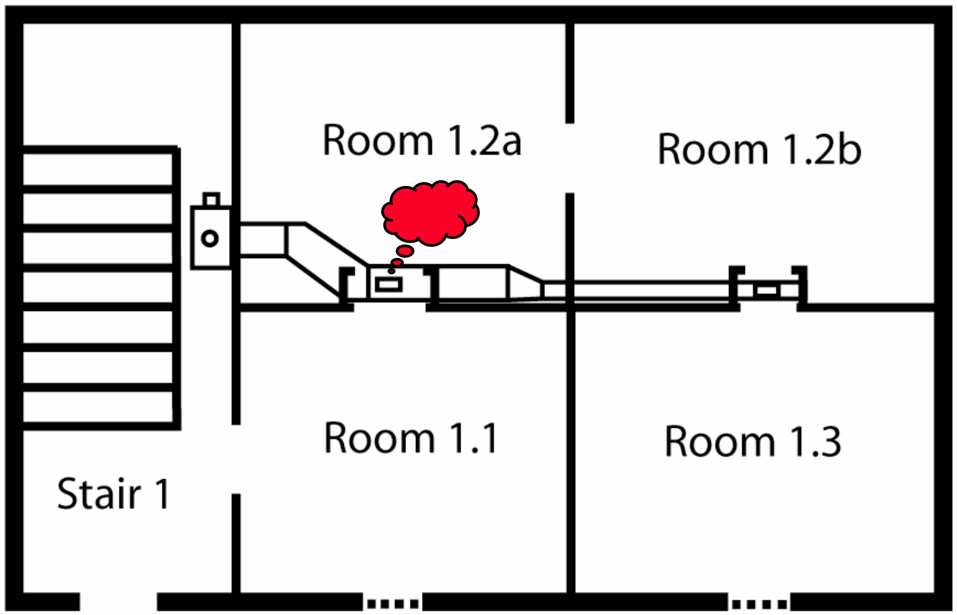
Illustrative Example:
Application to Real Building and Dataset

Test Facility at Dugway Proving Grounds, Utah

- A propylene tracer experiment represented a CB release event
- A tracer released at real possible source location: the intake of the HVAC in one of the rooms

Floor Plan of First Floor

- 3 floors
- 10 possible source locations
- Operational HVAC system
- Real-time sensors in each room
- Unknowns:
  — source location
  — source duration
  — source magnitude
  — door positions



Challenges to Test BASSET

1. Can we locate an unknown source by interpreting sensor data in real time?

   Sohn, M.D., Reynolds, P., Singh, N., Gadgil, A.J. (2002). Rapidly locating and characterizing pollutant releases in buildings: An application of Bayesian data analysis. *J. Air and Waste Management Association*, 52:1422-1432.

2. Can we locate an unknown source by interpreting trigger-type sensor data in real time?

   Sreedharan, P., Sohn, M.D., Gadgil, A.J., and Nazaroff, W.W. (2006). Evaluating sensor characteristics for real-time monitoring of high-risk indoor contaminant release. *Atmospheric Environment,* 40:3490-3503 2006.

3. Can we chose sensor performance characteristics when optimizing a network?

Challenges to Test BASSET

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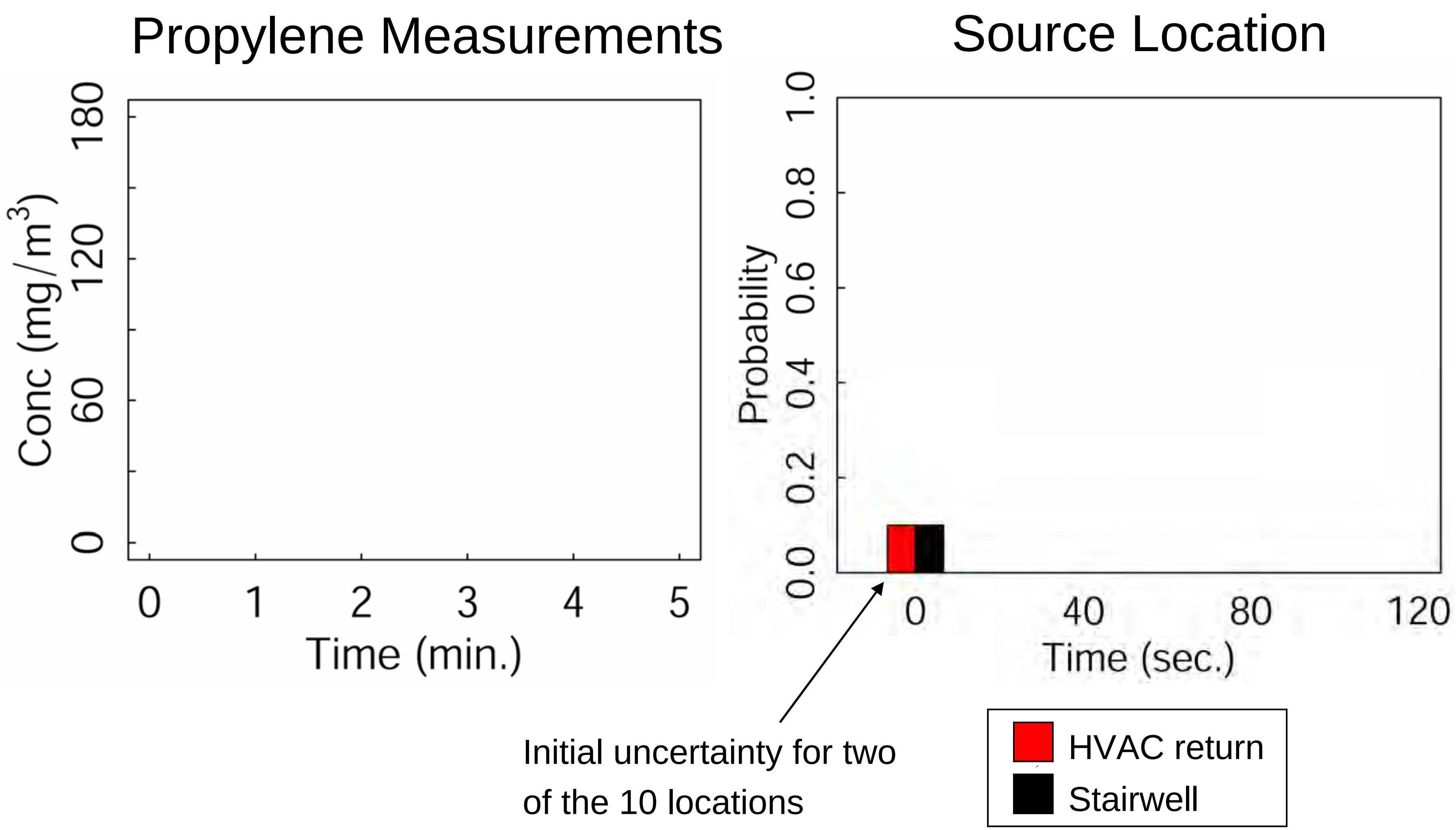
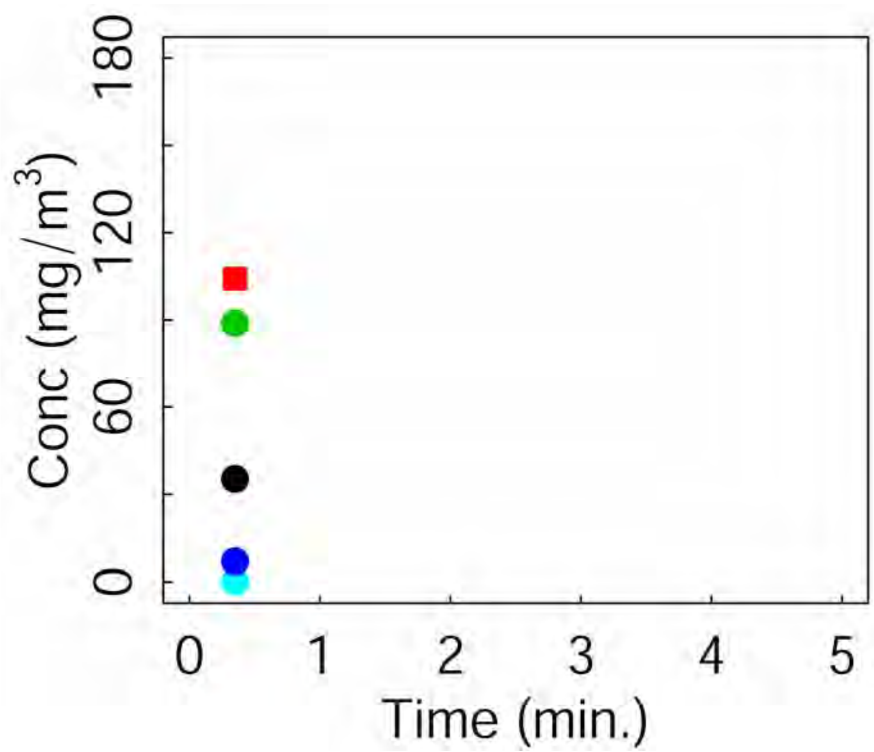
Estimating Source Location in Real Time



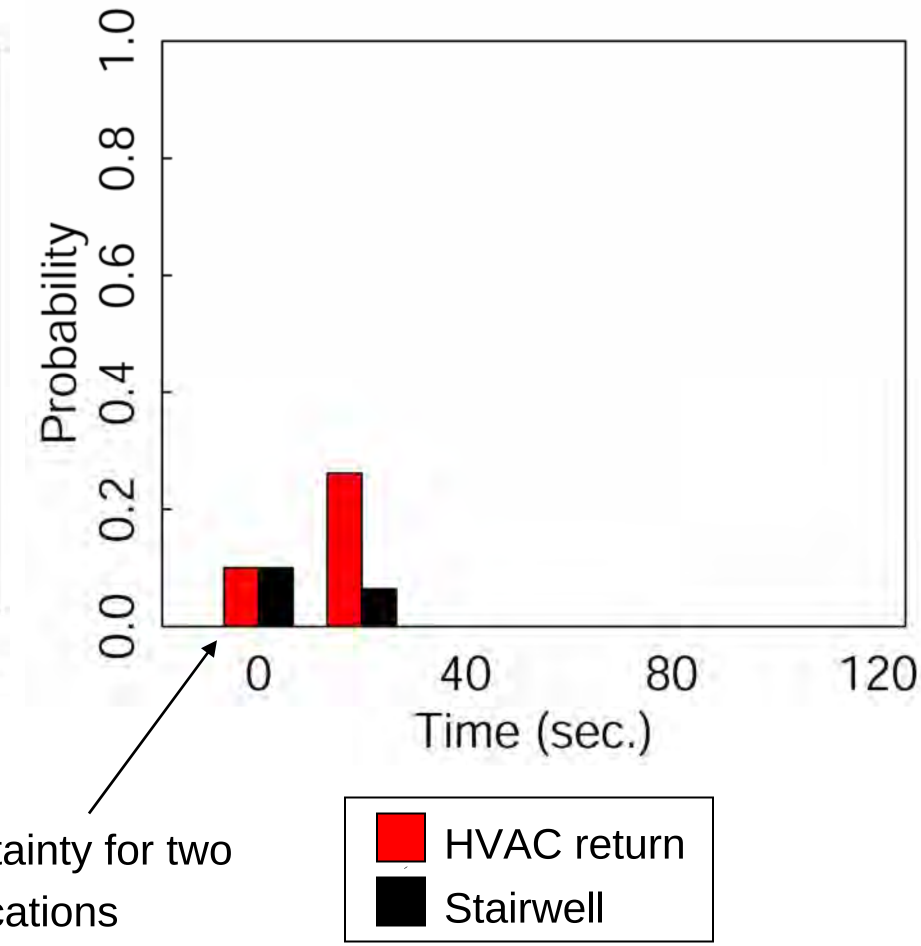
Initial uncertainty for two of the 10 locations

Estimating Source Location in Real Time

Propylene Measurements



Source Location



Initial uncertainty for two
of the 10 locations

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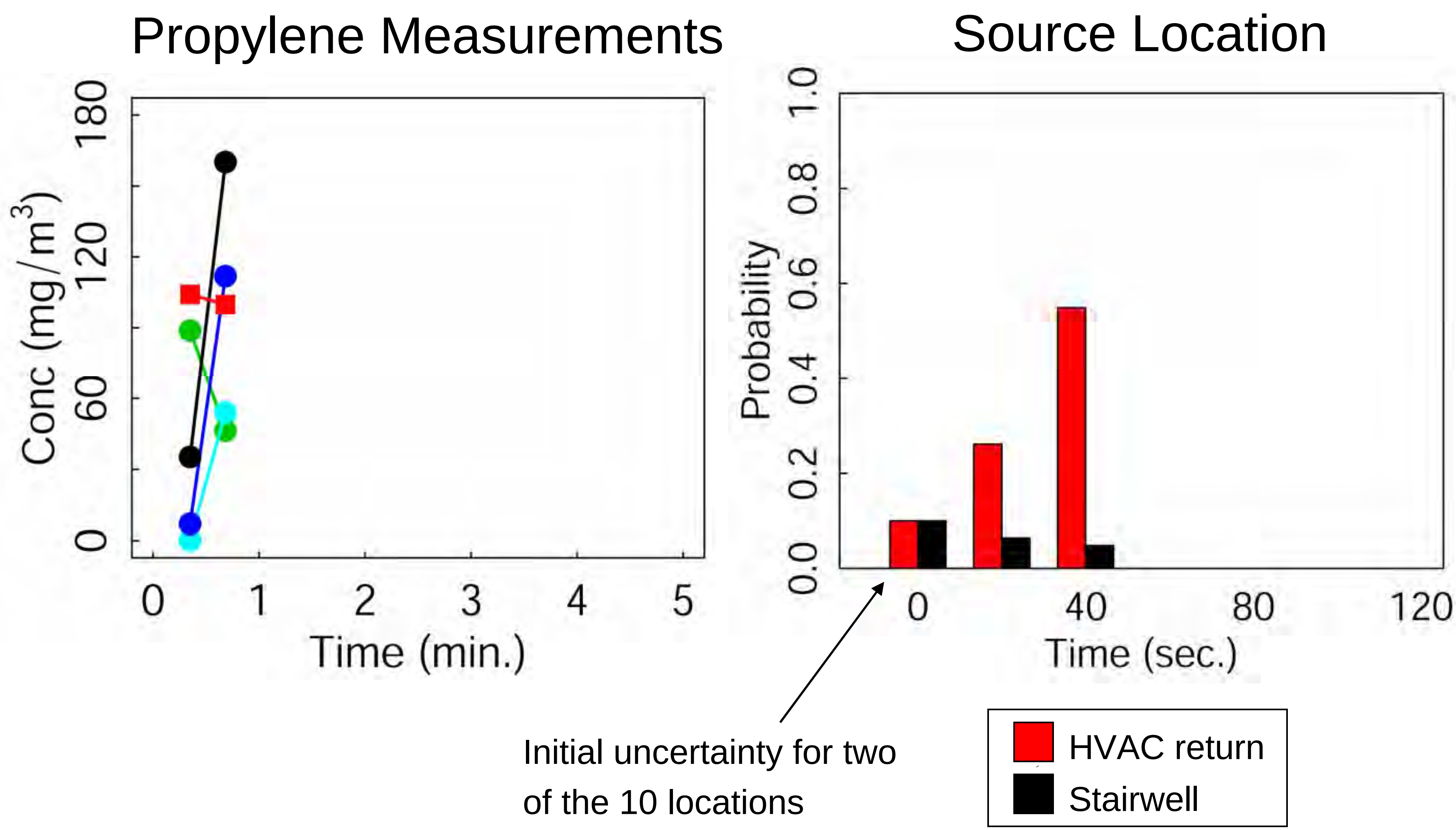
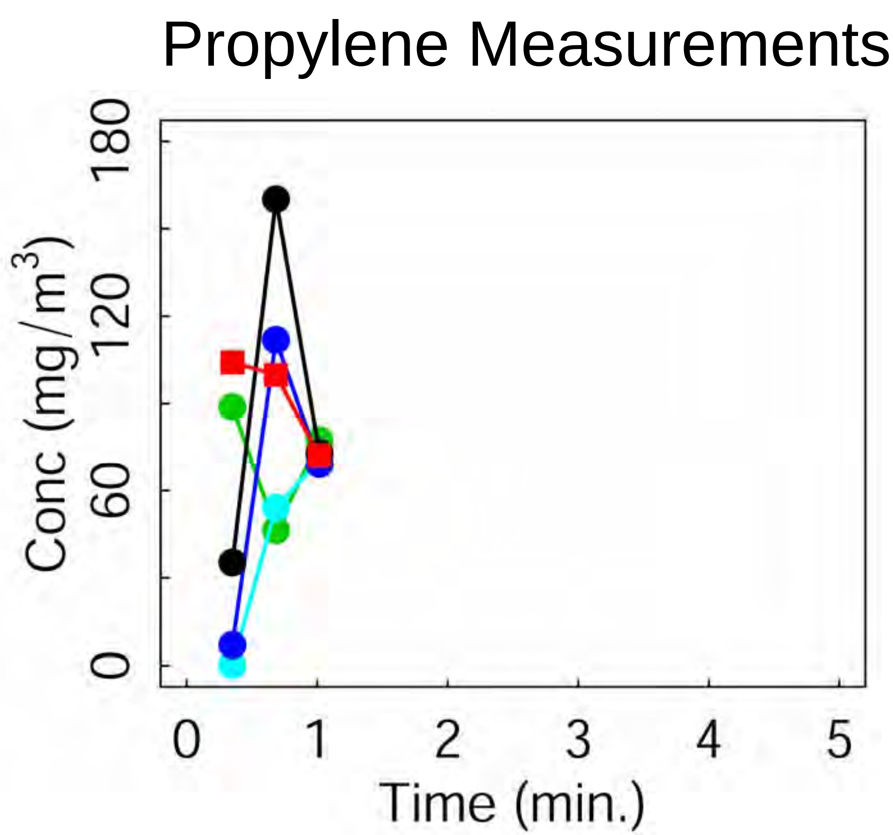
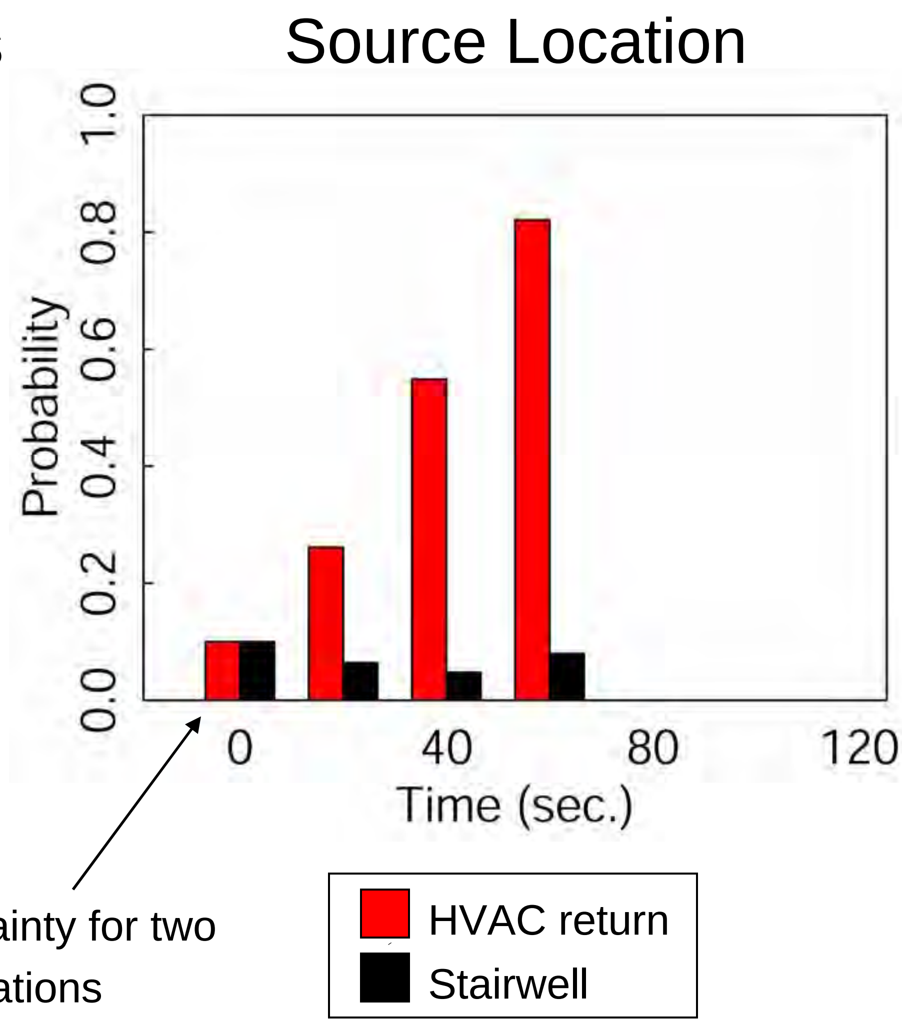
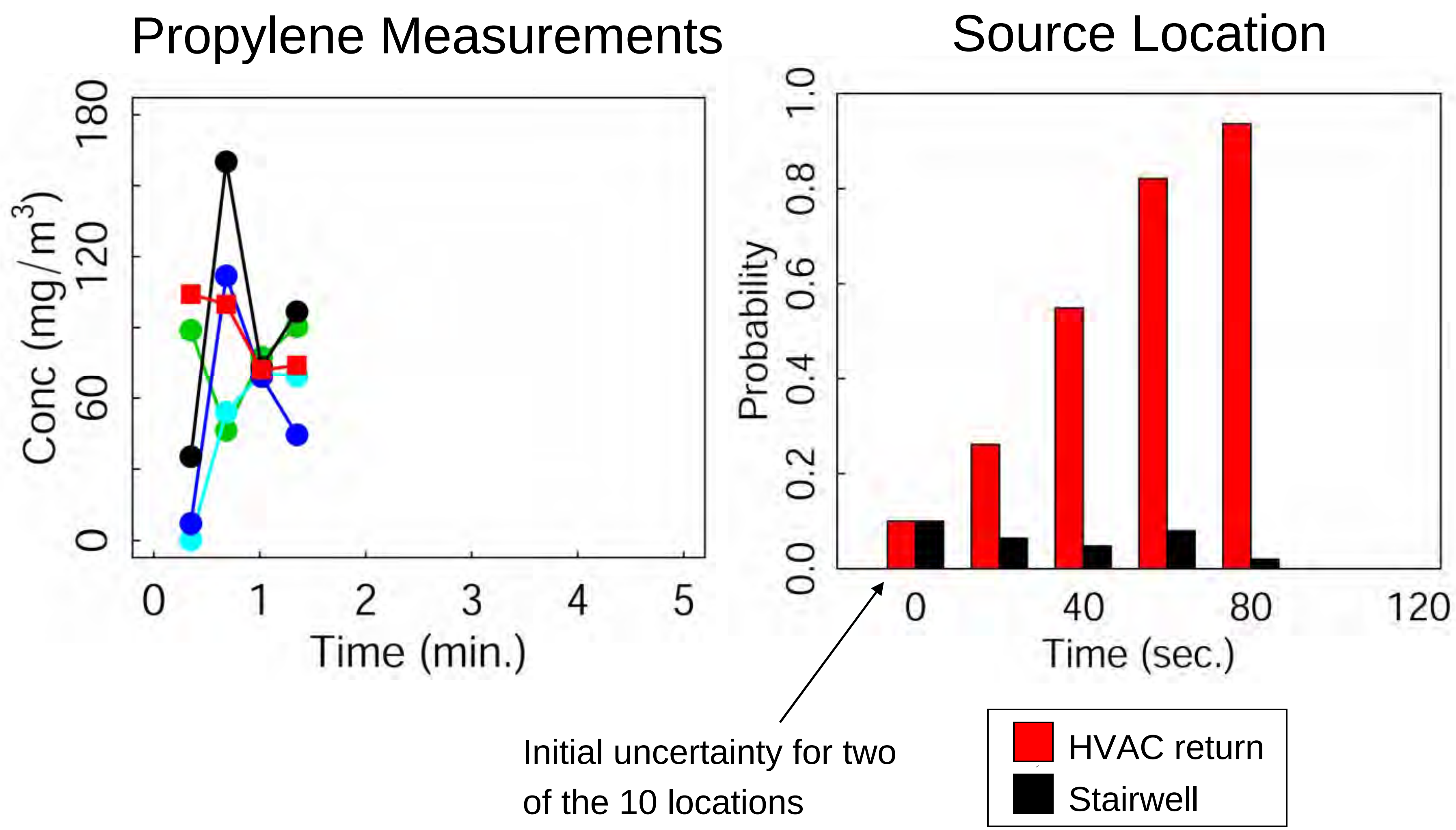


Estimating Source Location in Real Time



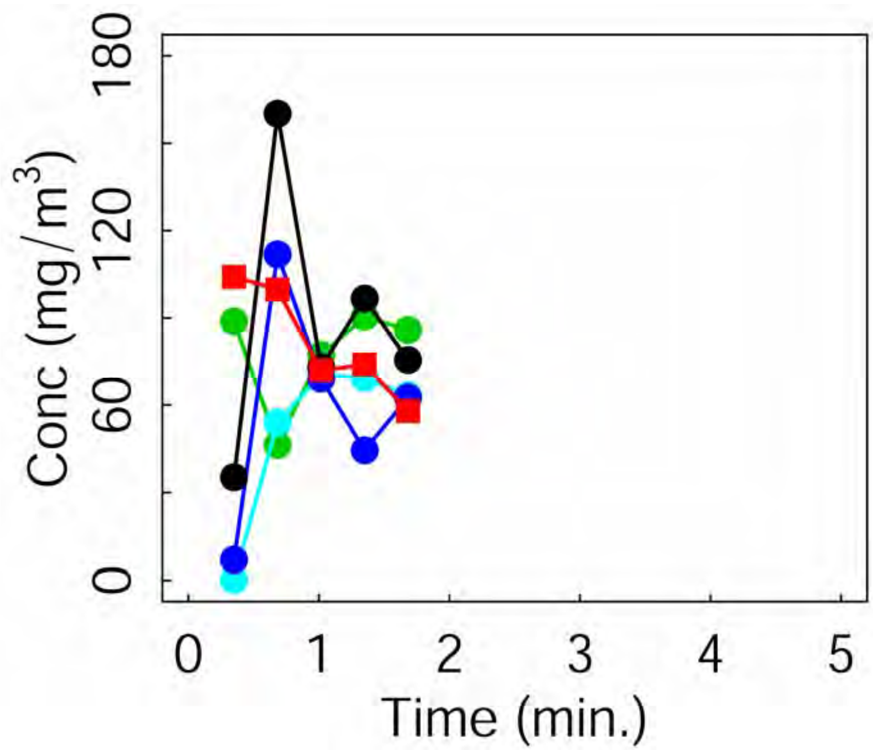


Estimating Source Location in Real Time

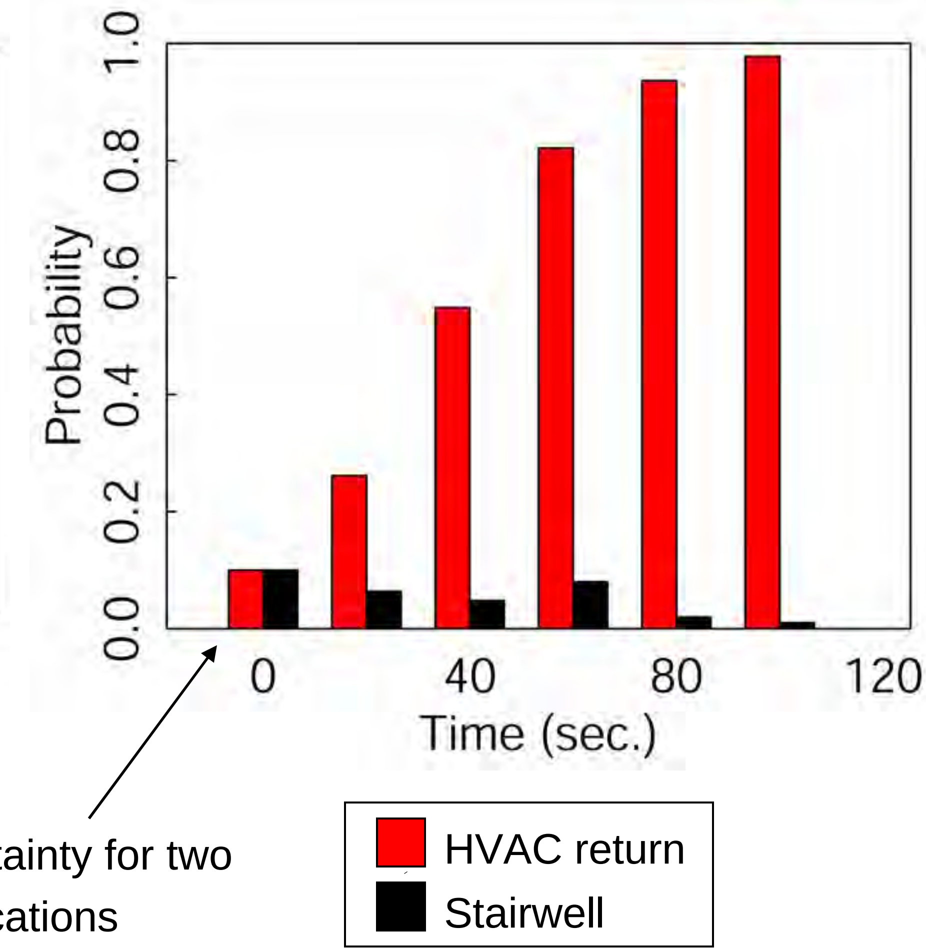


Estimating Source Location in Real Time

Propylene Measurements



Source Location



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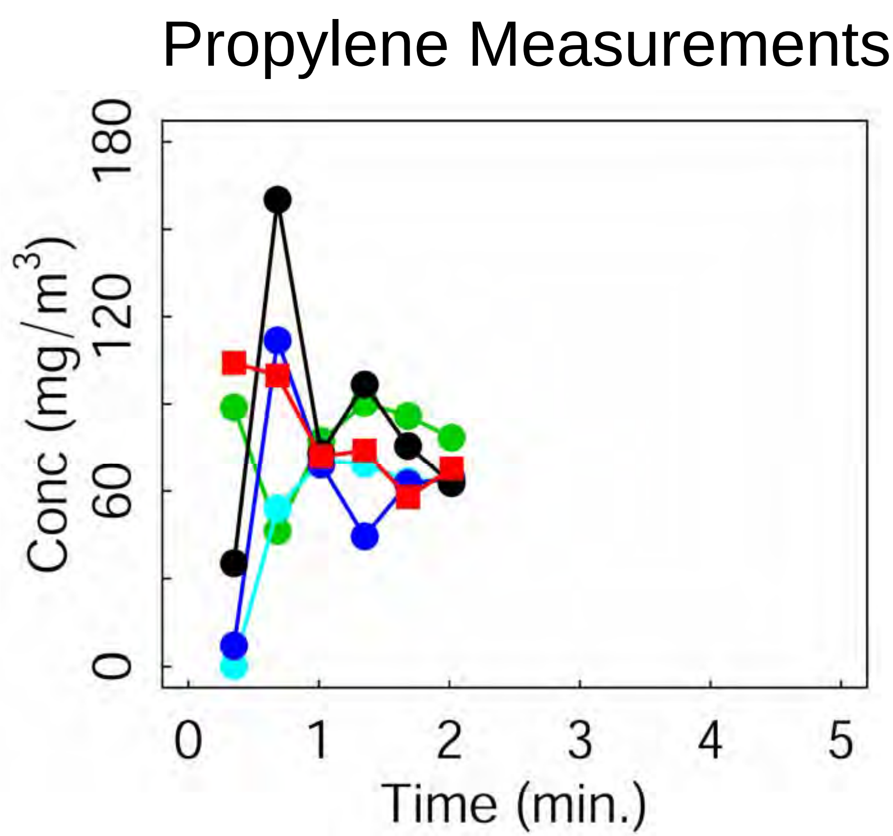
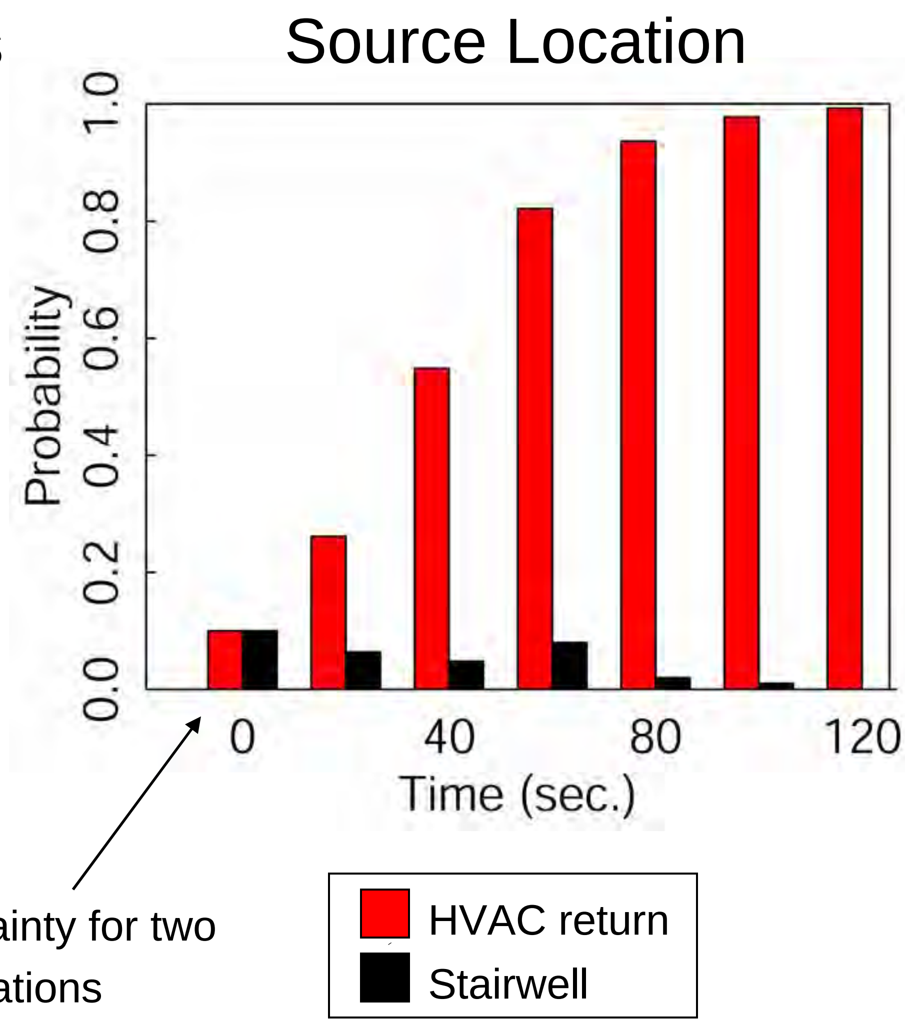
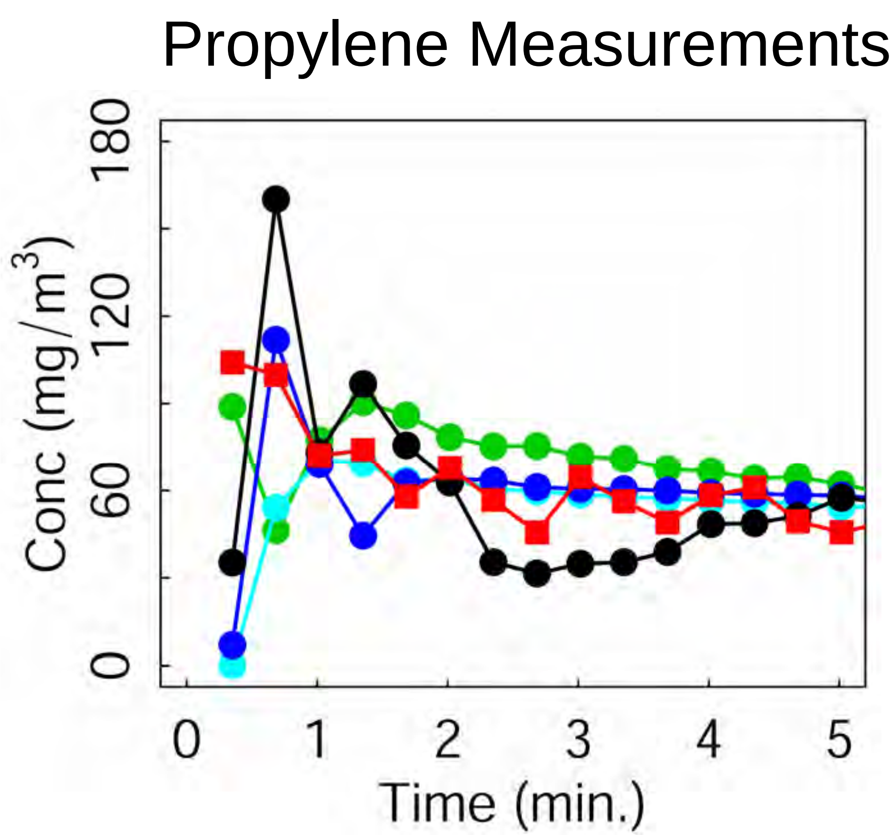
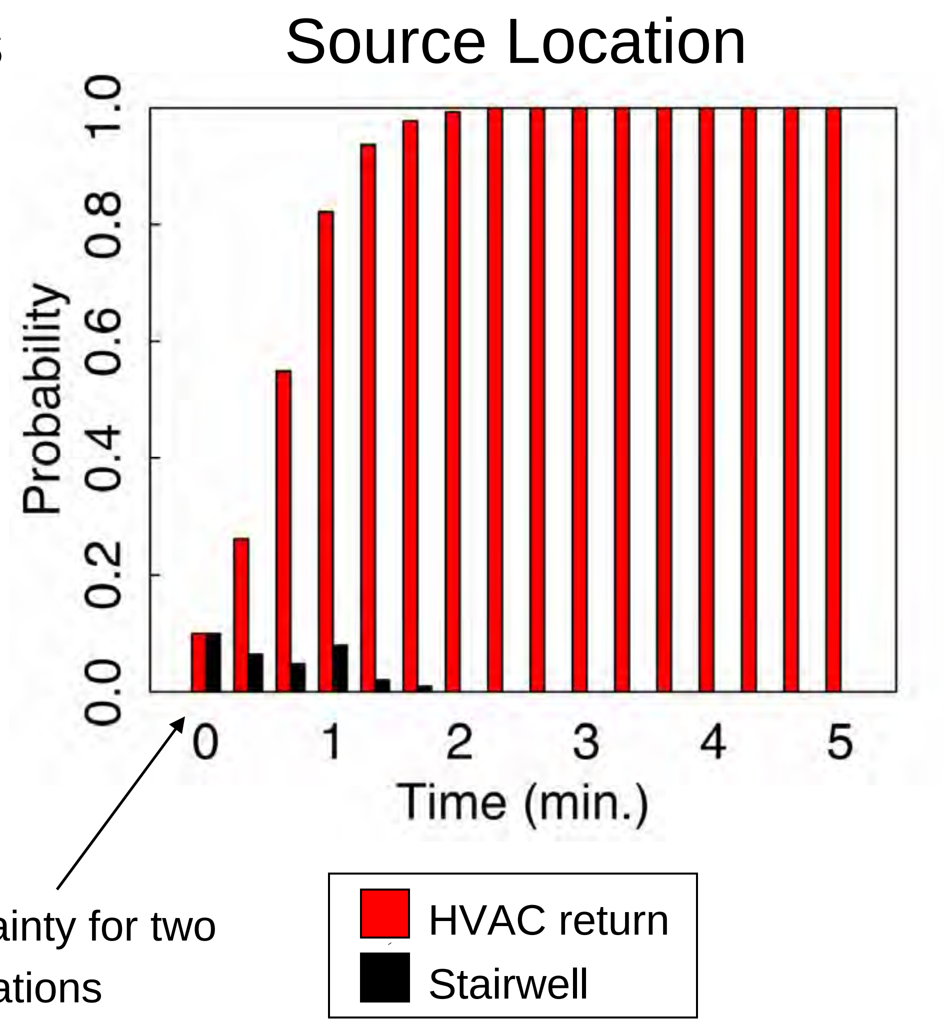
Estimating Source Location in Real Time





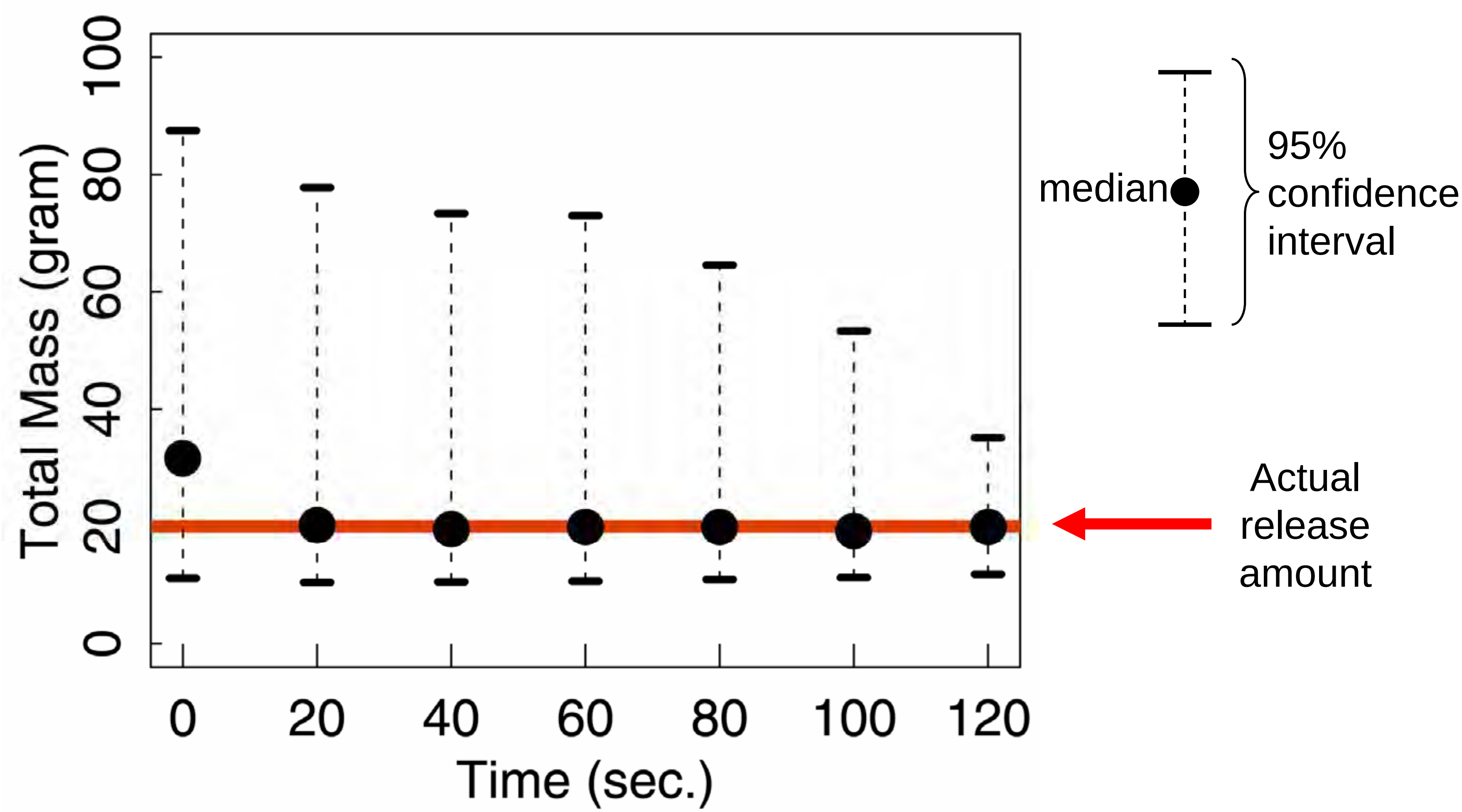
Estimating Source Location in Real Time





Initial uncertainty for two of the 10 locations

Estimating Amount Released in Real Time



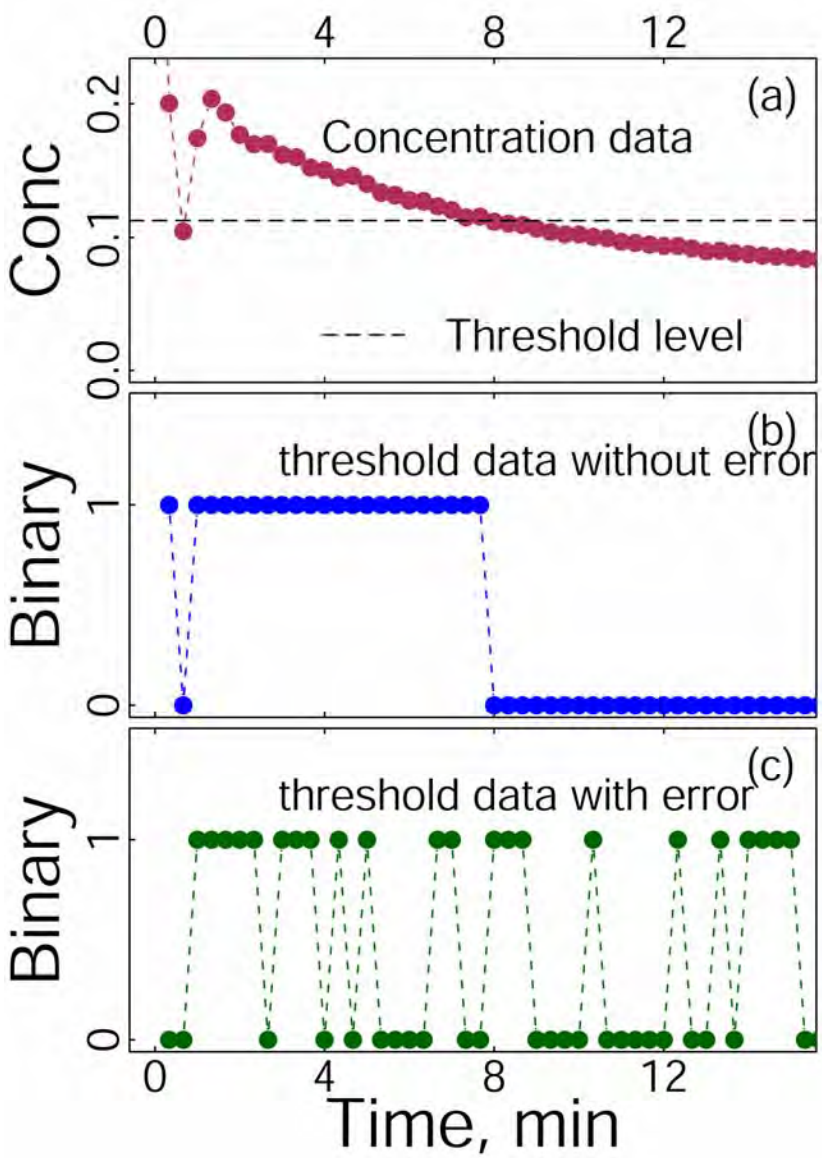
Challenges to Test BASSET

1. Can we locate an unknown source by interpreting sensor data in real time?

2. Can we locate an unknown source by interpreting trigger-type sensor data in real time?

3. Can we chose sensor performance characteristics when optimizing a network?

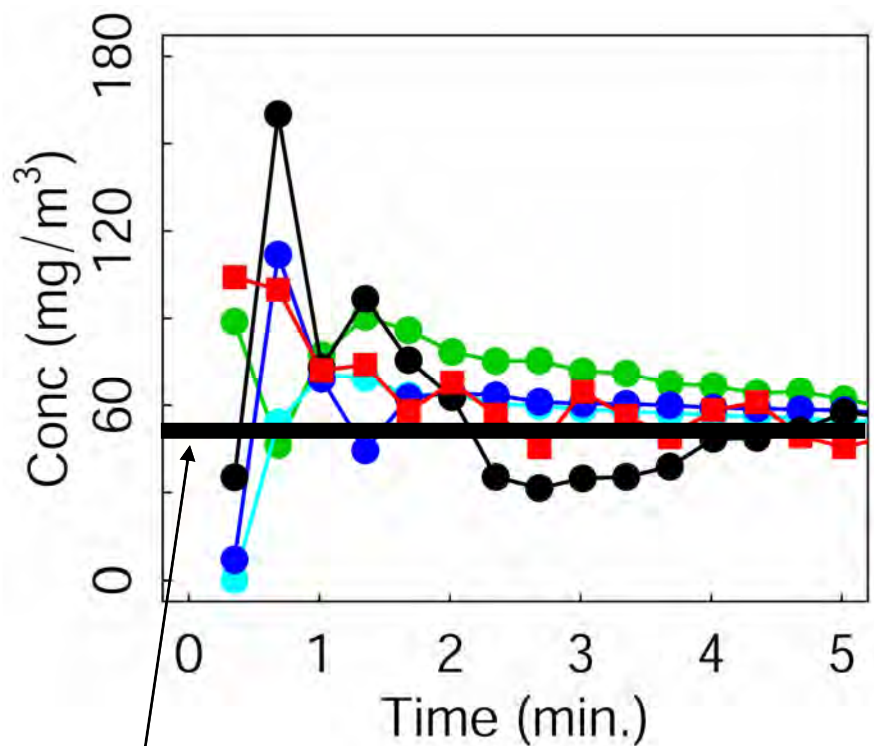
Can We Interpret Data Received as “Trigger” Alarms?



- Measurements above the line are flagged as a “1”, and those below as a “0.” BASSET only receives the flags.
- Flags are randomly corrupted with false positive and false negative rates. Tested rates of 10% and 30%.

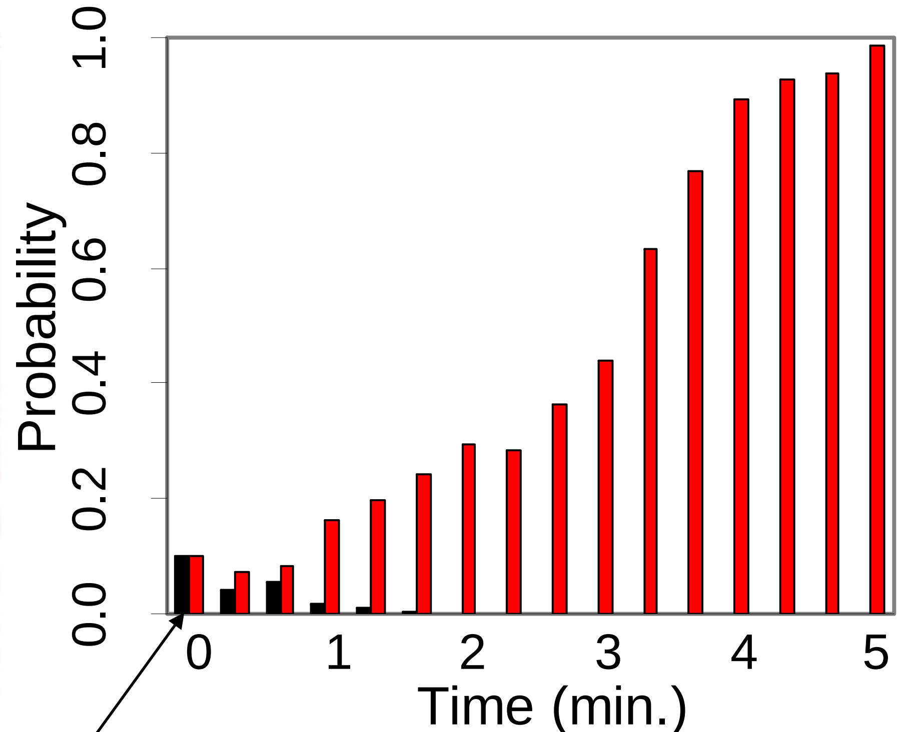
Locating Source using Trigger Alarms

Propylene Measurements



threshold = 55 mg/m^3
integration time = 20 sec

Source Location



Initial uncertainty for two of the 10 locations

HVAC return
Stairwell

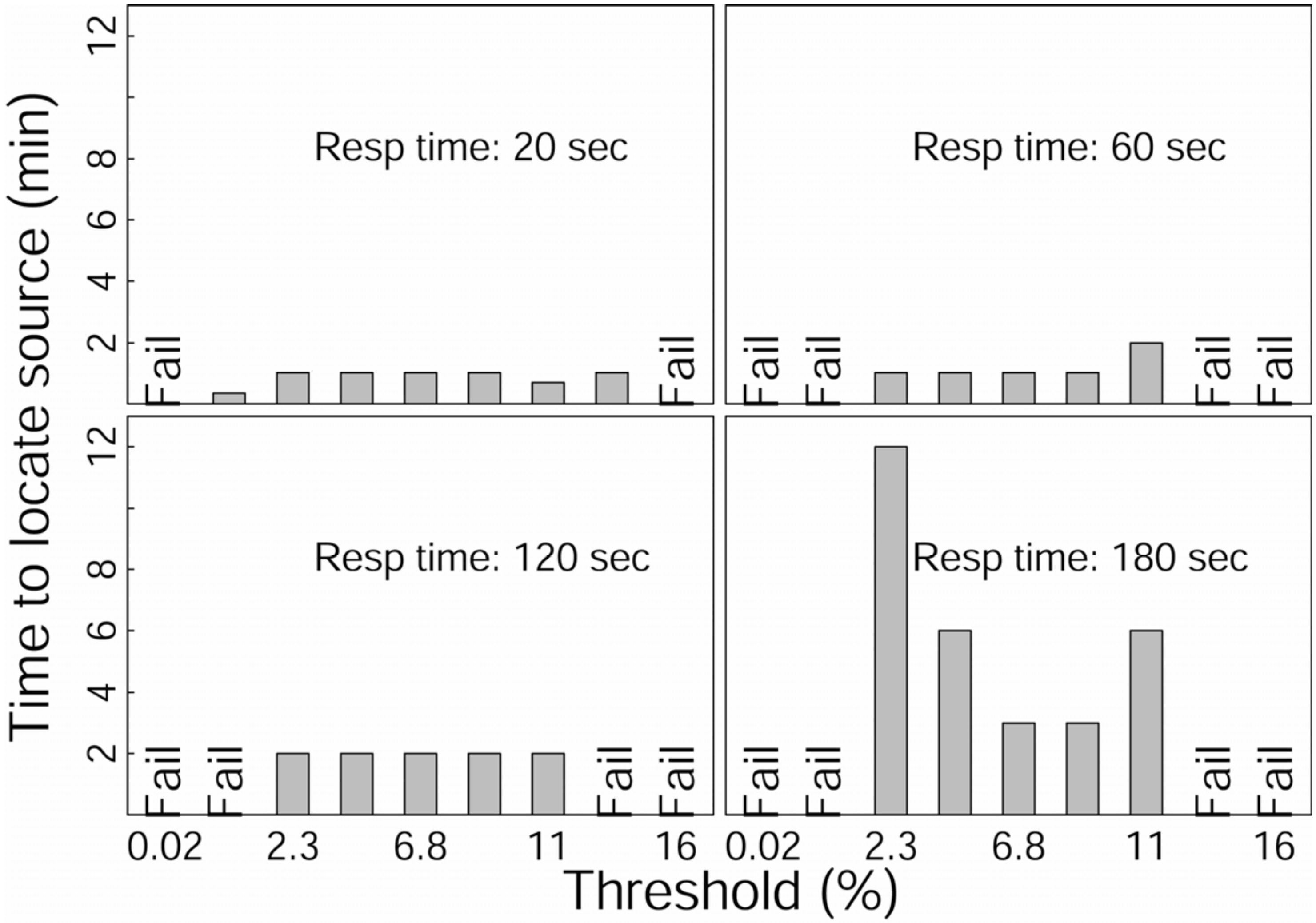
Challenges to Test BASSET

1. Can we locate an unknown source by interpreting sensor data in real time?

2. Can we locate an unknown source by interpreting trigger-type sensor data in real time?

3. Can we chose sensor performance characteristics when optimizing a network?

Trade-off Between Sensor Integration Time and Sensor Trigger Level



Summary and Concluding Remarks

- We have developed and demonstrated a successful framework for indoor detect-to-protect applications.

- The resulting software packages will be
  - — linkable to any suitable airflow and transport model
  - — capable of reading simple ASCII data feeds from various data sources (e.g., weather stations, pressure sensors, and sensor hardware)

Joint Warning and Reporting Network (JWARN)
Briefing to CBIS

January 2007

CDR Michael Steinmann, USN
JWARN Acquisition Program Manager
Joint Project Manager Information Systems
michael.steinmann@jpmis.mil

JOINT Warning and Reporting Network (JWARN)

Mission:

Enable immediate and integrated response to threats of contamination by weapons of mass destruction through rapid warning and dissemination of Chemical, Biological, Radiological and Nuclear (CBRN) information.

Warfighter Needs

- Collect, generate, edit and disseminate NBC reports and plots and provide a means of ensuring all addressees have received a sent message
- Application support for FBCB2, C2PC, GCCS-J, GCCS-M, GCCS-A, and GCCS- AF COE Level 7 / DODIIS
- Allow NBC reports (NBC-1/NBC-4) to be formatted and transmitted within 2 minutes and allow operator selection of automatic, delayed or on-command sending of NBC reports
- Automated sensor interfaces for M8A1, M21, M22, IPDS, ADM 300, AN/VDR2, JBPDS

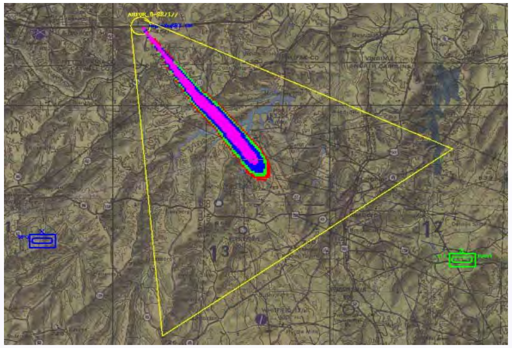
Description

- JWARN is an ACAT III (DOT&E Oversight Program) information system that networks NBC sensors, mission application software tools, and C4ISR systems
- JWARN builds on current manual capabilities by fully integrating with COE-based and tactical C4ISR systems
- Automatically generates alerts for warning and dewarning affected forces
- Automatically generates hazard area plots

Core Capabilities

JWARN provides the Joint Force Commander with the capability to:

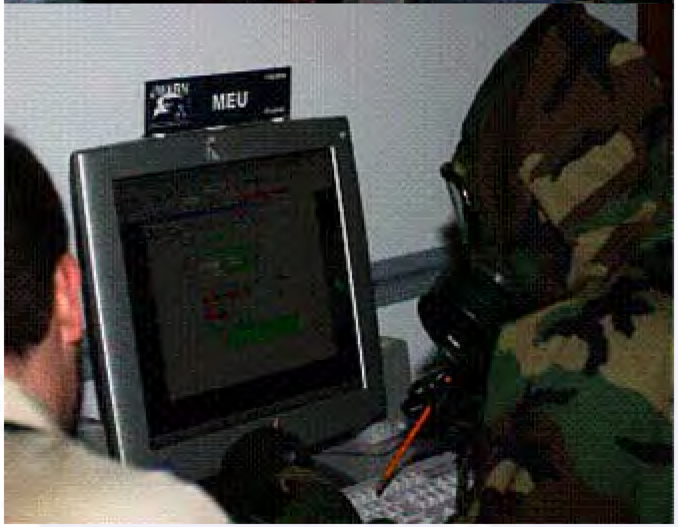
- Report CBRN and Toxic Industrial Materials (TIM) hazard detection
  - Collect, generate, edit and disseminate NBC plots on Command and Control (C2) platforms to provide a common operational picture (COP) for the warfighter
  - Collect, generate, edit and disseminate NBC reports (NBC-1/NBC-4)
- Analyze detections to enable identification of the hazard and plot affected locations
  - Auto generation of ATP-45 hazard warning area
  - Generation of more detailed hazard area plots using JEM



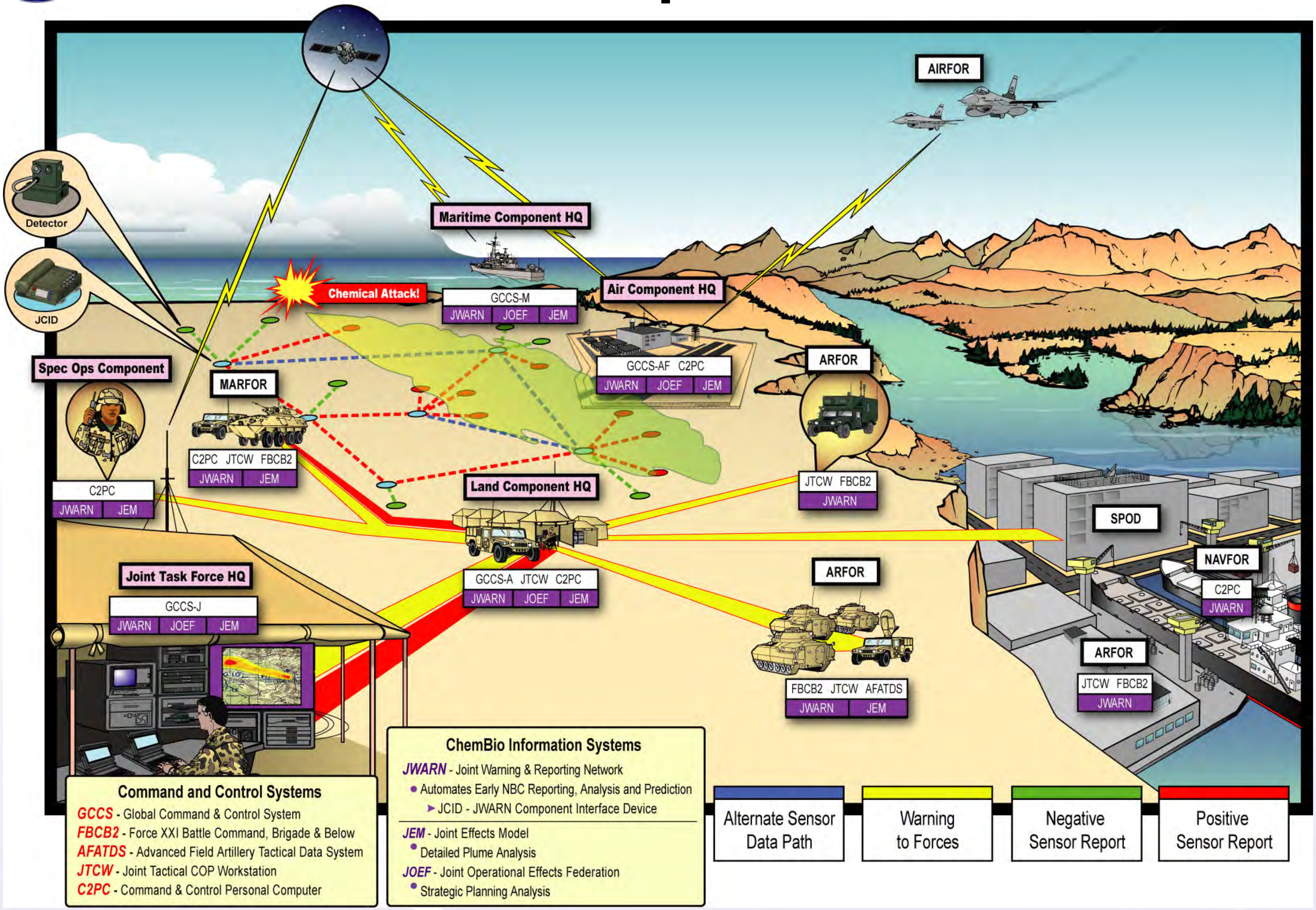
- Disseminate warning and de-warning information to affected units
- Auto retrieval and archiving of event data to enable post-operations forensic evaluation
- Control and configure a local sensor network
  - Auto sensor interfaces for M8A1, M21, M22, IPDS, ADM 300, AN/VDR2, JBPDS

Benefits to the Warfighter

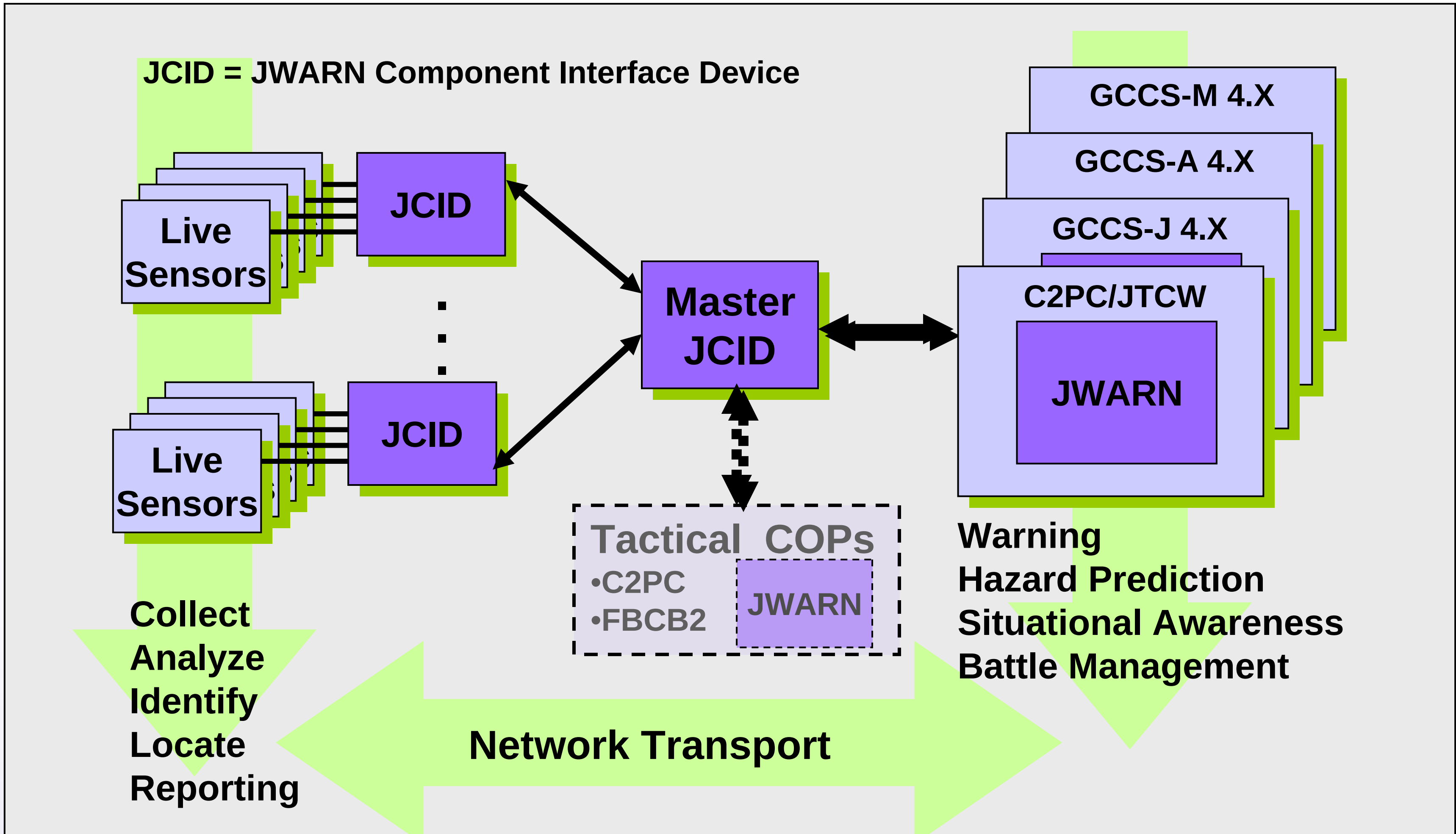
- **Automates a process which was previously manual and error prone**
- **Minimizes time from detection to warning (less than 2 minutes)**
- **Provides timely warning and de-warning of affected units to maximize combat effectiveness**
- **Automates recording and archiving of exposure data which will enable more effective forensic analysis**
- **Compatible and integrated with current and future Command & Control systems**



JWARN Operational View



JWARN System View

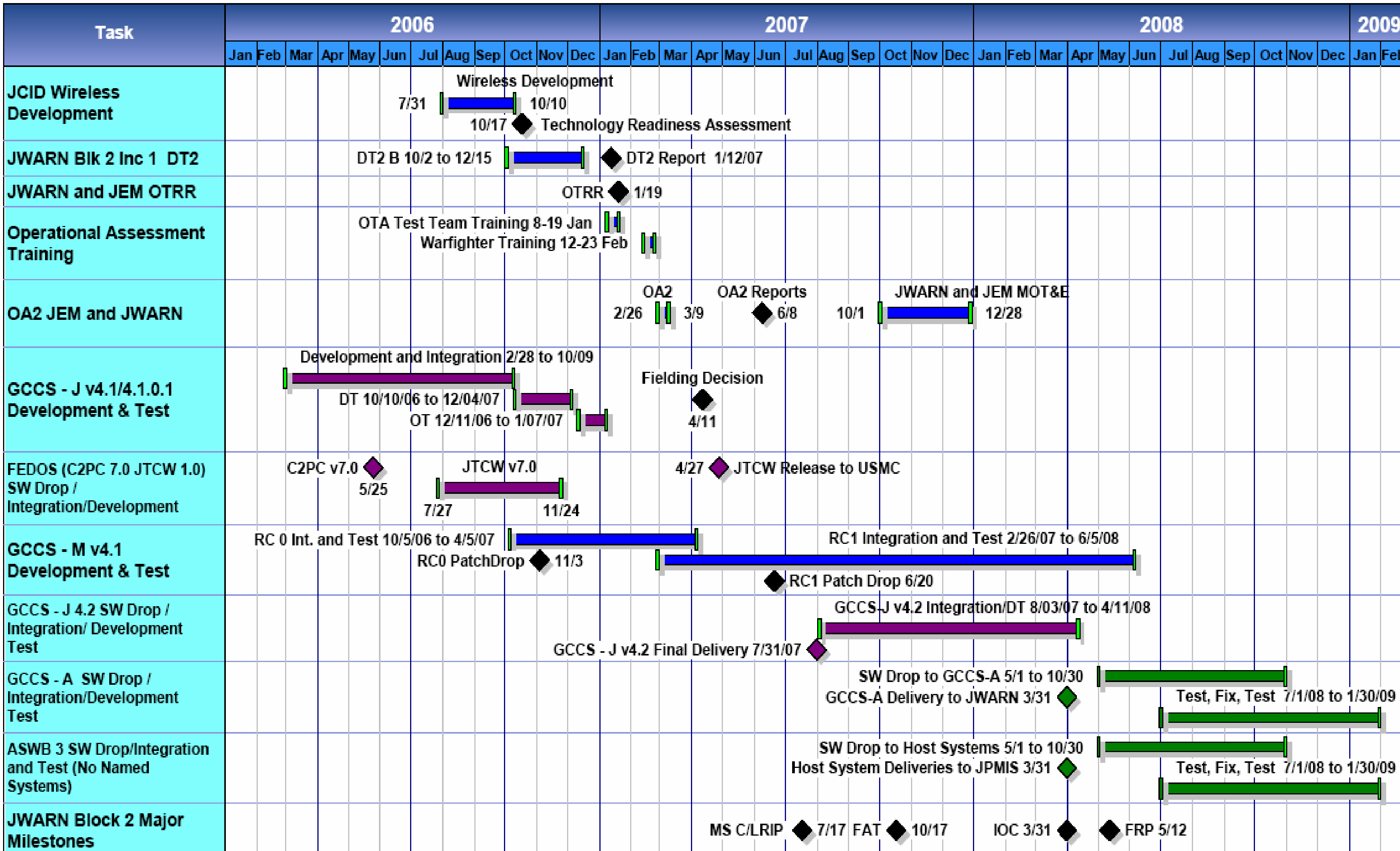


JWARN – Joint Sensor to C4I

Program Acquisition Strategy

- Two Increments of development followed by Pre-Planned Product Improvement
- Increment 1 (FY06 – FY09)
  - Increment 1 development complete
    - Developmental Testing and Operational Assessment in progress
    - Milestone "C" - July 07
- Increment 2 (FY08 – FY 12)
  - Increment 2 design and development FY08 – FY09
    - Maintain JWARN Baseline for various C4ISR systems
    - Accommodate new C4ISR systems
    - Web enabled
    - Full integration with JEM & JOEF
    - IOC FY10, FOC FY12

JWARN Program Schedule



JWARN Technical Challenges

- Integration of multiple Chem-Bio sensor interfaces (Legacy and Developmental)
- Compatibility with multiple Service-specific implementations of C2 systems
- Evolving national C2 system architecture(s)
  - Net Centric Enterprise Services (NCES)
  - Joint C2 (JC2)
- Web enablement
- Wireless connectivity incorporating Information Assurance (IA) requirements
- Integration with JEM, JOEF and other major acquisition programs

Interim Wireless JCID Solution

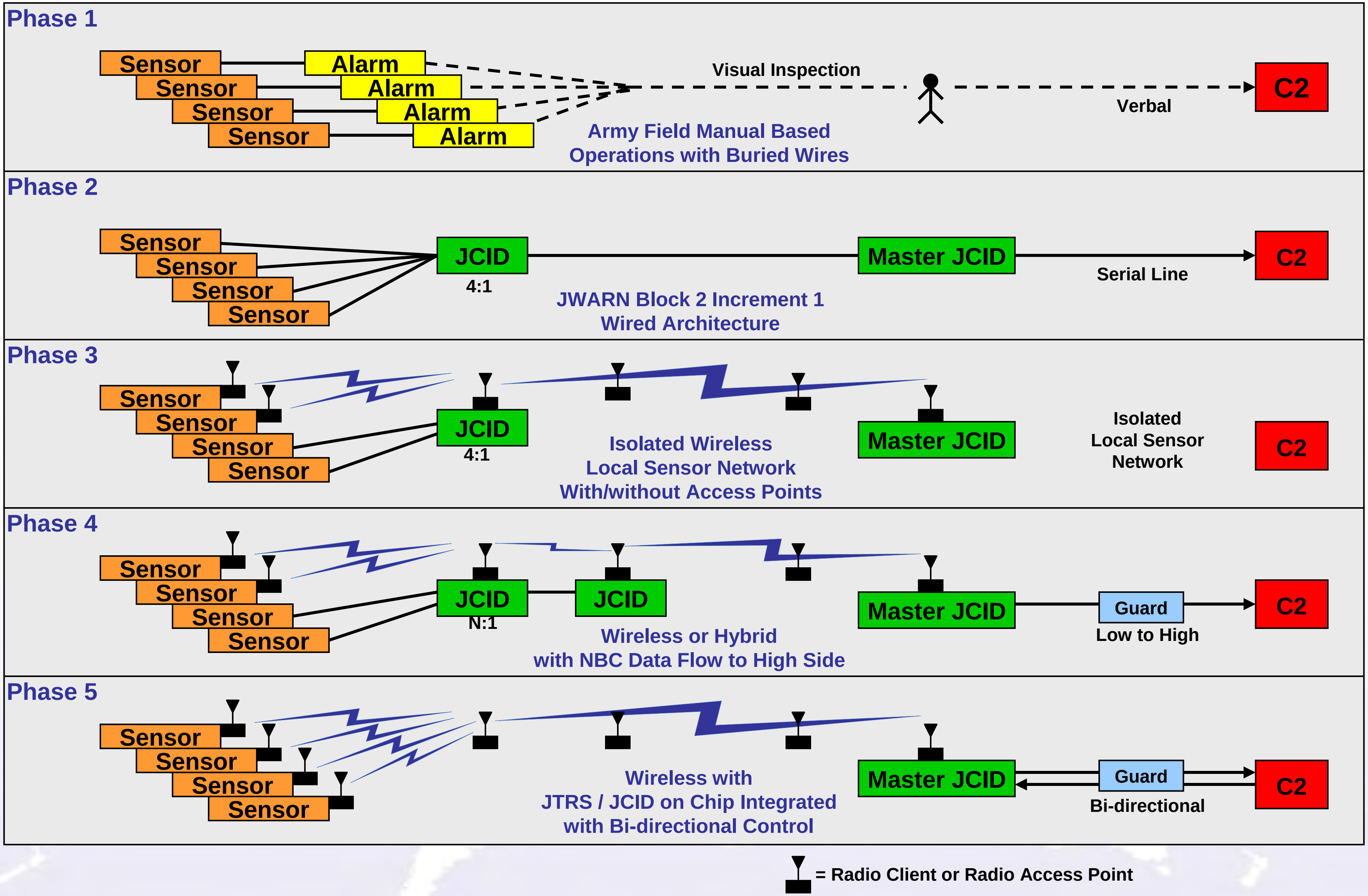
- **Wireless technology solutions exist**
  - **Provide sufficient coverage for typical air base**
  - **Supports rapid mobile dismounted deployment**
  - **Meet IA requirements**
  - **NSA certifiable**
- **Supports a “crawl”, “walk”, “run” development cycle**
- **Solution is radio and network “agnostic”**
  - **Preserves capability to backfit JTRS solution when available**

Requirements

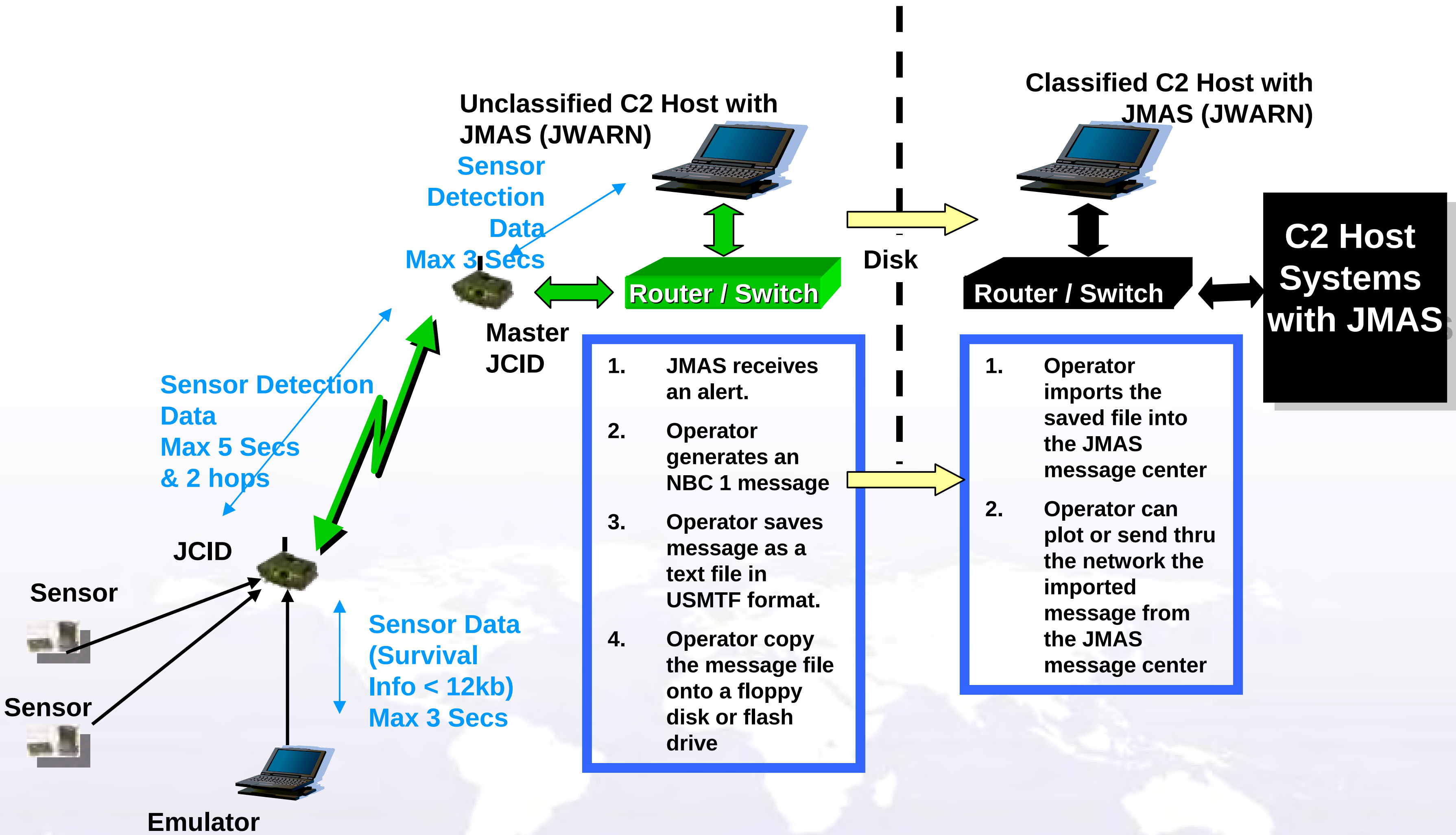
Simple “Radio Shack” solution

- Technology available now
- COTS/GOTS hardware
- Radio agnostic
- Currently Fielded (DoD or other Agency)
- Adaptable to current JCID and JMAS software
- Configurable to support Fixed Site (e.g. AF Base); Mobile/Dismounted applications
- Criteria includes Cost, Performance and schedule
- Solution can be ready for MOT&E (Oct-Dec ’07)
  - Implies DT/OA, Environment Tested, plus SSAA/IATO/C&A by NSA
  - Supports Wireless capability for MS/C (17 Jul 07) decision

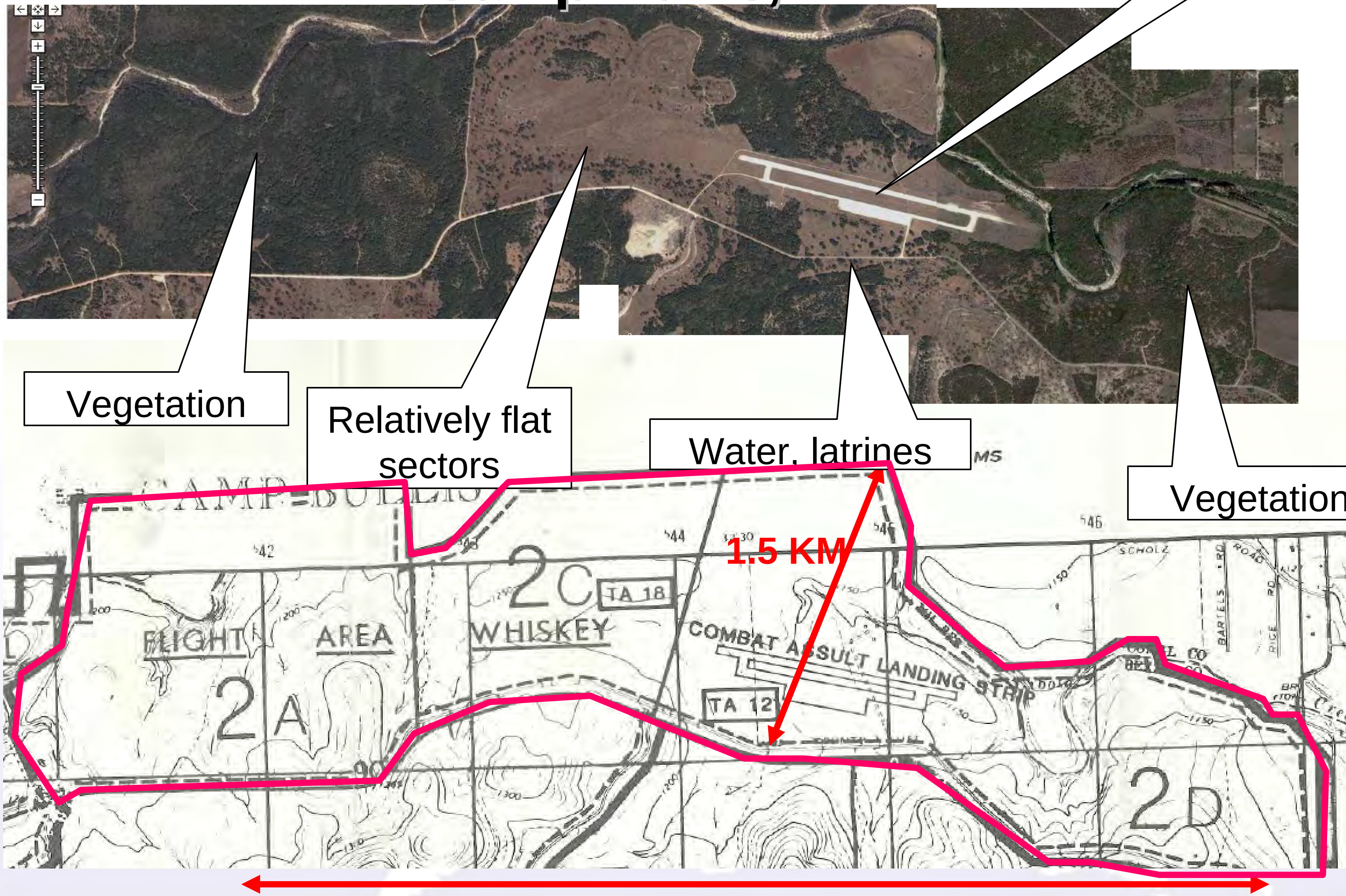
CBRN Sensor to C2 Evolution



Initial System Architecture

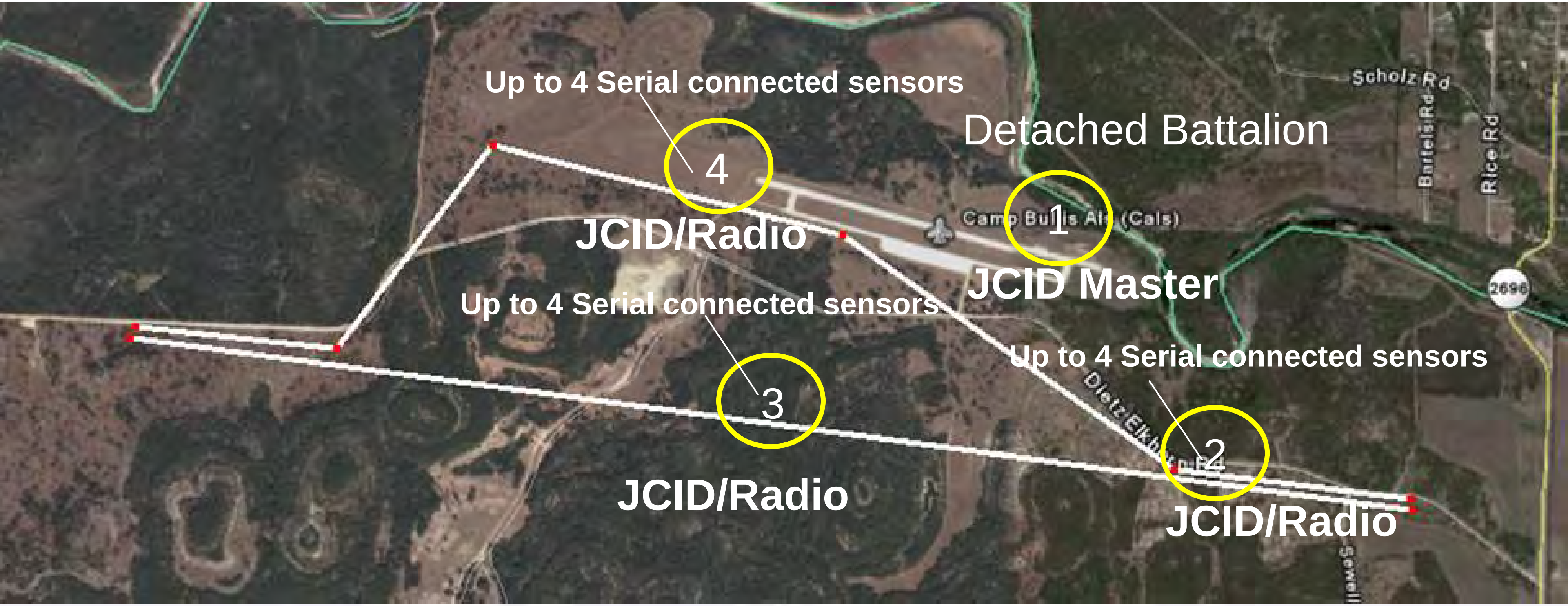


Wireless Assessment
Camp Bullis, TX



NOTE: Each grid square is a KM

Wireless Mesh Network Deployment



Circles indicate hardware placement

Wireless Path Forward

- Evaluate and procure COTS-based interim wireless solution to support MOT&E and IOC
- Assess prototype system by mid-October 06
- Conduct Wireless DT (Q3 07)
- Seek NSA certification for Cross Domain solution
- Procure sufficient numbers of wireless JCIDs to support MOT&E and IOC

Technology Transition Agreements (TTA)

Current Initiatives

- **TTA IS 008 - Sensor Alert Verification for Incident Operational Response (SAVIOR)**
- **TTA IS 015 - Shared Common Operational Picture (COP)**
- **TTA IS 016 – JCID Thin Client Server**
- **TTA IS 017 – InterLAN Service Connection Manager (ILSCM)**
- **TTA IS 021 – JCID on a Chip**

Sensor Alert Verification for Incident Operational Response (SAVIOR)

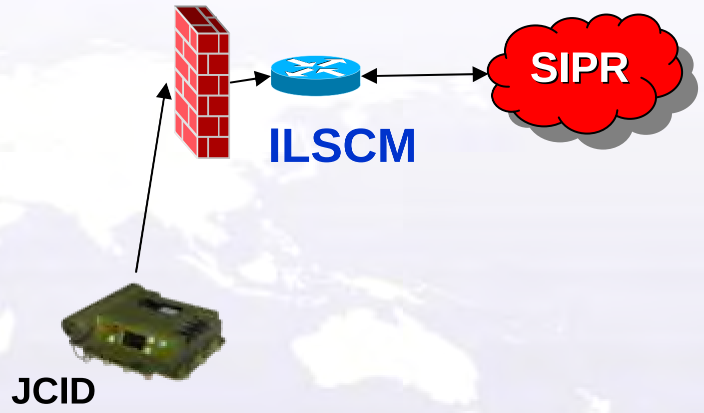
- **Description:** Develop information fusion algorithms and software to reduce chemical point sensor false alarms when used for fixed site protection.
- **S&T Goals:** Algorithms will be developed for jointly processing multi-sensor data from multiple sensor nodes as well as contextual information regarding sensor health and known activities that may affect air quality. Attempt to distinguish attacks from normal events by comparing the temporal response across a network of sensors to everyday occurrences to various attacks.
- **Transition Year:** 2008

JCID Thin Client Server

- **Description:** Develop a JCID thin client server that responds by sending files over a TCP-IP link (either wired or wireless) and communicating with the sensor in its proprietary protocol. Supported formats include HTML and XML as well as standard file encryption. Allow the incorporation of new detectors by modifying external spreadsheets. Simple tables (editable in a spreadsheet) are modified to define the parsing of the digital sensor information into elements of a sensor XML schema and HTML page.
- **S&T Goals:** The objective is to take an existing sensor interface device, developed for chemical sensor fusion, enhance its capabilities to meet JCID compliance and demonstrate this capability for JWARN within 12 months. Deliver 25 units in one year.
- **Transition Year:** 2008

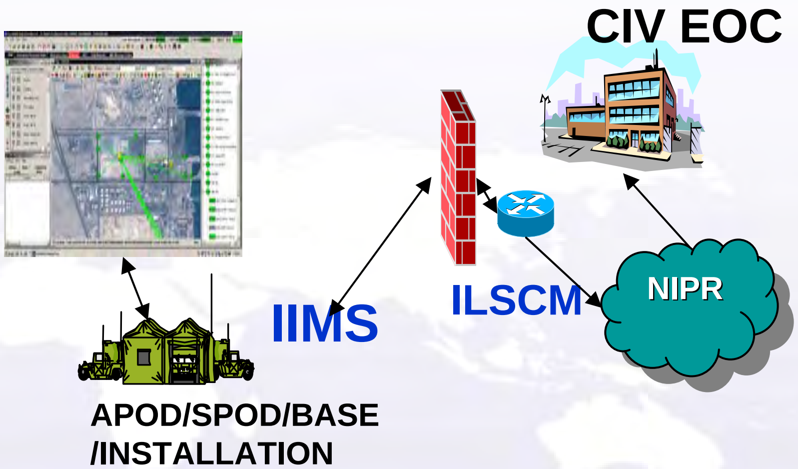
InterLAN Socket Connection Manager (ILSCM)

- **Description:** Employ a bi-directional data guard to provide secure data between unclassified networks and classified networks.
- **S&T Goals:** Adapt existing technology from the Tomahawk program to build a data guard between a sensor network and a C4I system. Process the solution all the way through the DITSCAP process and get an IATO.
- **Transition Year:** 2008



Shared COP

- **Description:** Shared COP explores issues related to sharing information between .mil and .gov networks. Investigate cross enclave information sharing issues.
- **S&T Goals:** Data sharing, messaging standards, cross domain guard solutions, information presentation, accessibility issues, data relevancy
- **Transition Year:** 2007

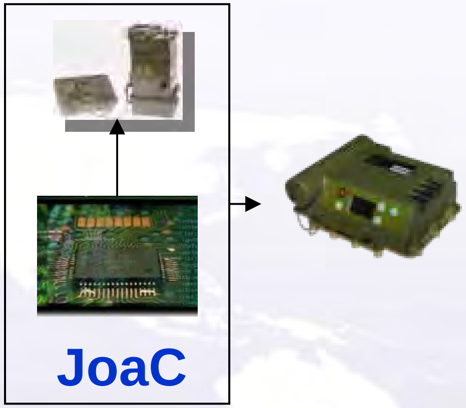


JCID-on-a-chip (JoaC)

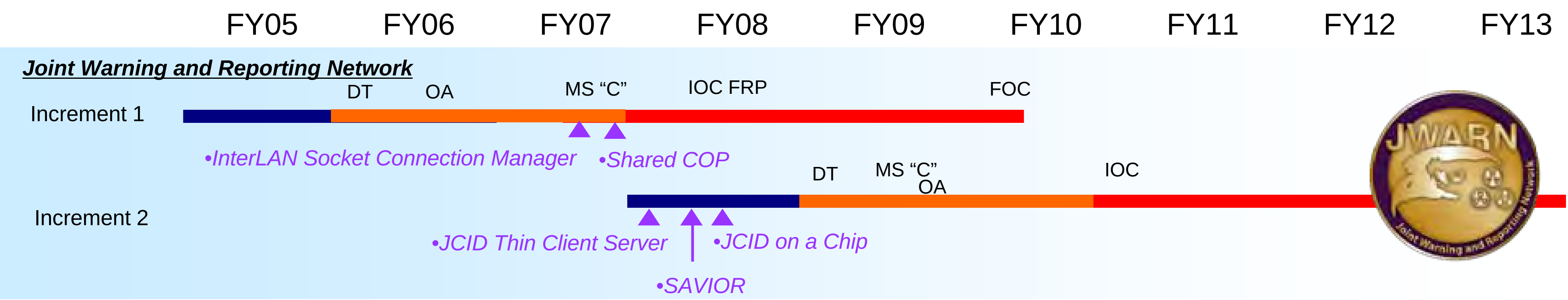
- **Description:** This effort proposes a software-defined sensor concept, architecture and approach to developing Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) sensors and CBRNE sensor capability that is hardware independent and can support the ability to load to key supported hardware sensor system technologies, e.g. Field Programmable Gate-Array's (FPGA).

- **S&T Goals:** Build software and/or firmware solution for embedding within future detectors. Work with JPM CA and JPM IS and others in the CBRN COI to develop standards. Collaborate with developers of Holster

- **Transition Year:** 2008



Acquisition Pull: The Technology Transition Paradigm



Backup Slides

What is a Mesh Network

- **Mesh Networks are an advancement in the 802.11x technology.**
  - **A mesh network is a self forming self healing network that forms multiple connection paths between access points by creating a routing table of available access points, thus providing redundancy by rerouting communications.**
  - **A high performance mesh access point contains at least two radios, one which forms the connection point for end users, and the other radio forms the backhaul connection or relay point between the access points in the network.**
    - **In a single radio mesh, the client traffic and mesh traffic share the same radio link, putting traffic on the same channels. This effectively cuts the mesh network performance by two-thirds at a minimum.**
  - **The NSA has approved the usage of 802.11x networks and set the requirements for security for the usage of 802.11x. These guidelines are laid out in the 8100.2, the security requirements dictated in this instruction are being enforced within the Mesh network deployments.**

A Proposed Open System Architecture for Modeling and Simulation (OSAMS)

A Service Oriented Architecture (SOA) for the M&S Community…

Jeffrey S. Steinman, Ph.D.

JPEO CBD
Software Support Activity
Integration and Test

Motivation…

- **How would our lives improve if the cost of M&S was reduced by *an order of magnitude?***
  - **How about *two orders of magnitude?***
- **M&S provides a cost effective way (and sometimes the only way) to support many challenging applications**
  - **However, we believe that the true potential cost savings for M&S has not been realized!**
- **If we are going to reach these potential cost savings, we cannot continue doing things the same way**
  - **Current M&S interoperability standards are not adequate**
  - **Revolutionary, not evolutionary change is needed**

Interoperability Standards

- **Current interoperability standards allow simulations to interoperate**
  - **However, there are no standards for how to build models!**

We should be building models, not simulations!

- **OSAMS provides standards that specify how to build highly interoperable models**
  - **OSAMS-compliant simulation engine required to host models**
  - **OSAMS-compliant models must not deviate from the API**
  - **OSAMS is part of a bigger *Standard Simulation Architecture* (SSA) that has been carefully constructed to support interoperability with other standards such as HLA, DIS, TENA, and web-enabled SOAs**

Some Basics… What is M&S

Model

A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.
DIS Glossary of M&S Terms, DoD Directive 5000.59, DoD Publication 5000.59-P and MSETT NAWC-TSD Glossary

Simulation

A method for implementing a model over time.
DoD Directive 5000.59 and DoD Publication 5000.59-P

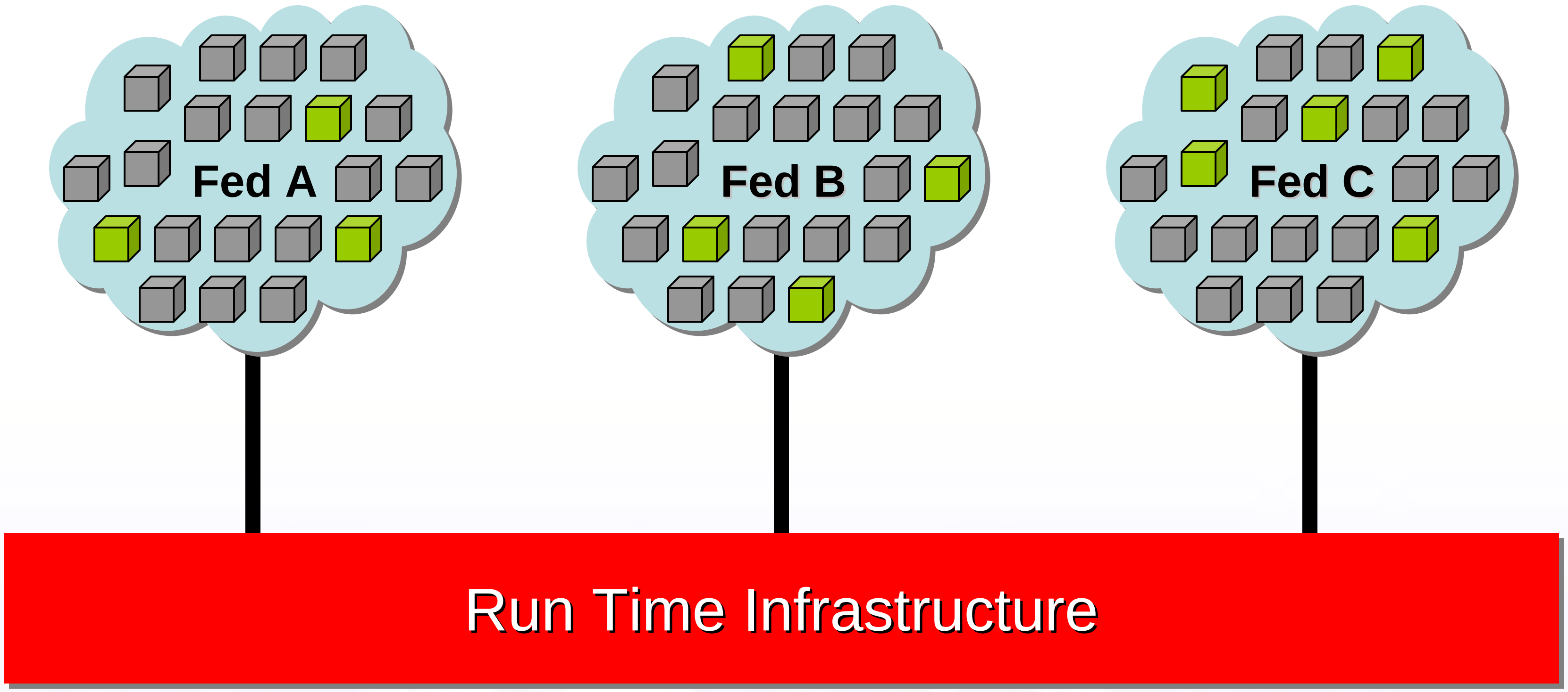
Modeling & Simulation (M&S)

The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions. The terms "modeling" and "simulation" are often used interchangeably.
MSETT NAWC-TSD Glossary

From a Software Developer Perspective

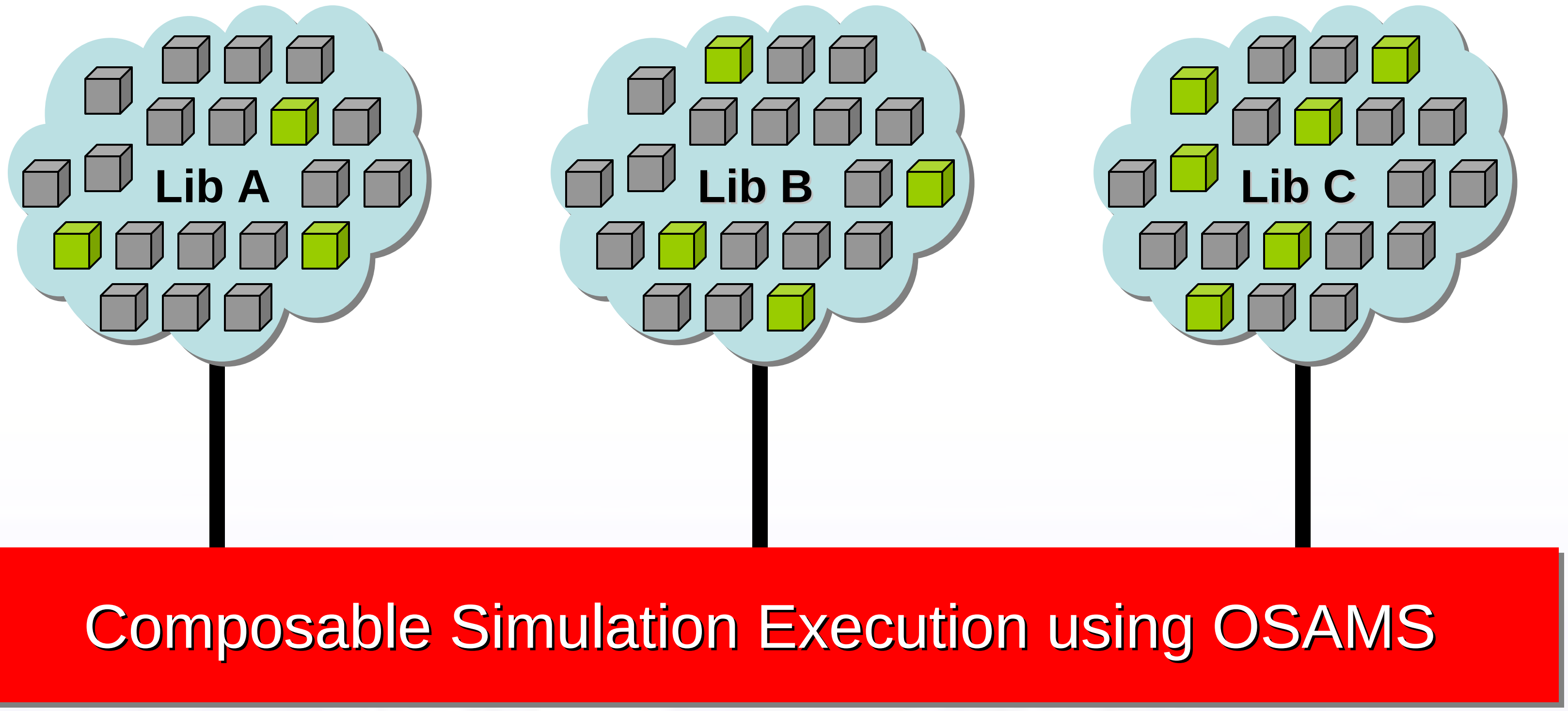
- **Terminology: Simulations**
  - **Simulations are programs that are composed of models**
  - **Simulations generally require a simulation engine to provide core event-scheduling and event-processing services that allow models to advance in time**
- **Terminology: Models**
  - **Models are software representations of systems**
  - **Models can be self contained and therefore be reusable if…**
    - **Independent of the simulation engine (does not coordinate the passage of time)**
    - **Independent of other models (does not directly invoke methods on other models)**
    - **No reliance on shared global variables (encapsulation)**
  - **But… More likely, models are tightly coupled to the simulation engine, other models, utility services, and global variables (in other words, models are generally not reusable)**

Current Interoperability Strategy
Simulation-to-Simulation Interoperability



- Integrating entire simulations when only select models from each federate are required…
  - High integration costs
  - Expensive and clumsy to operate
  - Unavoidable performance and fidelity tradeoffs

The Proposed OSAMS Strategy
Model-to-Model Interoperability



- **A better approach is to create model repositories/libraries that can be linked together to form a composable simulation…**
  - **Low integration costs**
  - **Easy to operate**
  - **High performance and fidelity**

Modern Applications of Plug-In Composability

- Many modern applications support plug in strategies to support interoperability between components developed by different vendors
  - Web services (SOA)
  - Graphics art
  - Office productivity tools
  - Video games
  - Entertainment systems
  - Wireless networks
  - Music software
  - CBD sensors in NCES environment
- So why not provide a plug-in SOA approach to provide model interoperability?

Plug and Play for M&S

- **Model interoperability is much more difficult than traditional plug in systems because different categories of models require different interfaces (and there are a lot of them…)**
  - **Requires standardizing common types of interfaces such as sensor detection and track data, communications, command and control, various representations of complex motion, human intelligence, rules of engagement, etc.**
  - **Requires a plug-in strategy that decouples highly interacting model components**
  - **Also requires composability tool that verifies associations with other models when they are plugged in**
- **Polymorphic and publish/subscribe data exchanging techniques provide decoupling between software modules while still promoting full model interoperability**
- **Potential timing issues between models in their interplay affects where models should reside in network environments**

Simulation Engines

- **What simulation engines provide**
  - **Simulation engines provide the core event-processing infrastructure and language semantics required to enable the development and execution of complex models. Simulation engines allow applications to coordinate their processing activities in simulated time, which can be synchronized to the wall clock for real-time systems, or unconstrained for as-fast-as-possible synthesis and data analysis runs.**

Simulation Engine & Models

Wall of Separation

M&S Technology	CBD Model Representations
Simulation Engine (Focus on Services)	**Overarching Models** (Focus on Models)

- Commonly used modeling constructs and software utilities
- All network-related operations automatically provided
- Capabilities and technology advances leveraged by all models
- Simulation engine implements an Application Programming Interface

- Focus is on models, not infrastructure or bookkeeping
- Composable interoperability provided between models
- Form repository of models that can be reused
- Models plug into the simulation engine and use the API

Hardware Composability

- **Hierarchically Composing a Federation onto Hardware**
  - Federations are composed of networked federates
    - *Milliseconds*
  - Federates are composed of one or more machines
    - *Less than a millisecond on local area networks*
  - Machines are composed of processing nodes
    - *Microseconds if using shared memory*
  - Nodes are composed of threads
    - *Nanoseconds for context switching between threads*
  - Threads are composed of functions
    - *Much less than a nanosecond for function or method calls*

☛ **Performance spans more than six orders of magnitude**

☛ **Must apply reasonable hardware composition strategy**

Model Composability

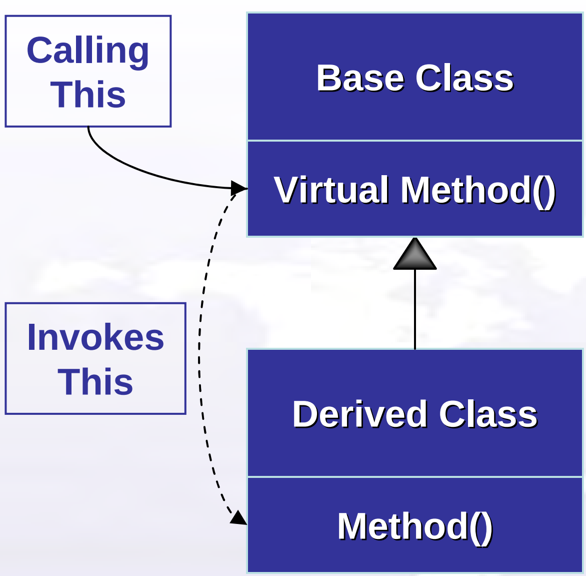
- **Hierarchically Composing a Federation from Models**
  - Federations are composed of federates
    - *Communication through RTI*
  - Federates are composed of entities
    - *Entities may reside on different processors*
  - Entities are composed of components and Federation Objects
    - *Components within an entity are on same processor*
  - Components are composed of subcomponents and Federation Objects
    - *Hierarchical composition is recursive*

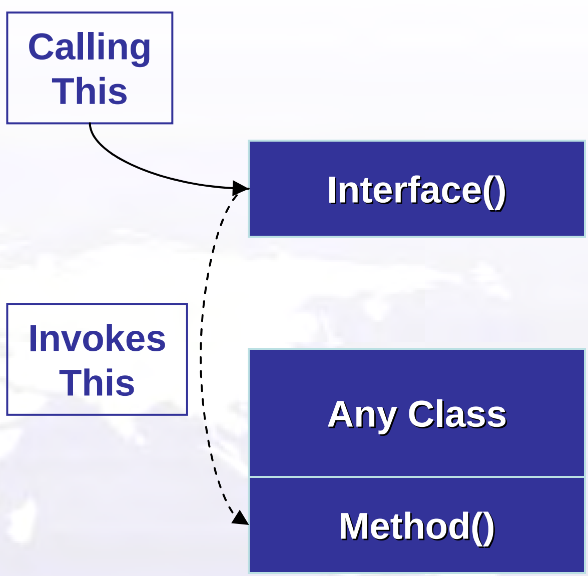
OSAMS provides the required APIs that support…

- **Flexible hierarchical model component construction**
- **Modeling framework for scheduling events**
- **Abstract interfaces to support component interactions**
- **Distributed object abstractions to support network operation**
- **Data logging and trace file generation for debugging, analysis, and VV&A**

Polymorphism Conceptualized

- *Old school* polymorphism was accomplished through class inheritance and virtual functions that are implemented by the derived classes. This approach is supported by all object oriented languages.
  - Inheritance required
  - Method names must match
- A more *modern* way to accomplish polymorphism is to define abstract interfaces that can be dynamically registered by class methods during run time. This is similar to the SOA methodology.
  - No inheritance required
  - Methods can be named anything

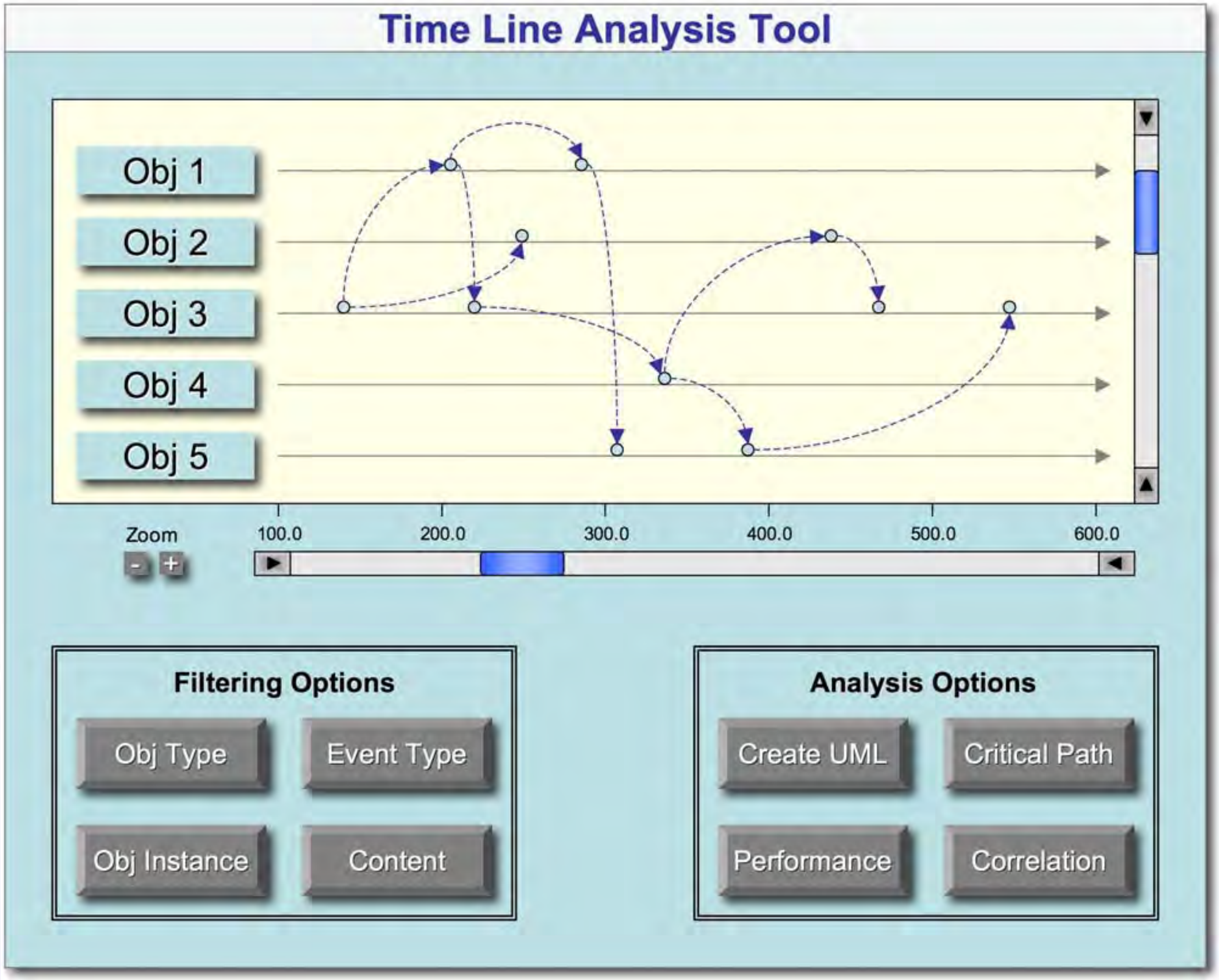




Architecture Rules for Model Interoperability

- **Must preserve the abstraction that an entity may reside on any node when running in parallel, or within any federate when executing in an HLA federation**
  - **Entity state exchanged with other entities must be provided exclusively through Federation Objects**
  - **Entities interact with other entities exclusively through HLA-style Interactions**
- **Key to automating interoperability with HLA… Entities behave like miniature federates!**
  - **Entities are special SimObjs that are distributed to different nodes or federates when executing in parallel and/or distributed environments**
  - **Distributed object capabilities support HLA-like functionality between entities**
  - **Operator overloading in C++ can automate distribution of attributes**
  - **Interest management automatically operates on attributes**

Trace File Generation and Time Line Analysis Tools



Summary of Composability Architecture Rules and Properties

- **Completely passive and encapsulated models with no relationships to other objects are automatically reusable**
  - **However, these kinds of models are rarely developed or openly shared**
- **To promote interoperability and reuse, all other models…**
  - **Must support a flexible *hierarchical composition structure* with the ability to define, compose, and construct simulation objects at run time**
  - **Must be allowed to advance time through services that are provided by a *standardized modeling framework* and compliant simulation engine**
  - **Must rely on *abstract polymorphic interfaces* to decouple interacting models**
  - **Must support *distributed object capabilities* to automate interoperability with legacy systems in a federated publish/subscribe environment and to support high performance computing**
  - **Must support *data logging interfaces and trace file* generation to support testing, debugging, analysis, and VV&A**

An Open Standard Architecture for Modeling and Simulation (OSAMS) is required to promote model-based interoperability and reuse

How to Proceed with OSAMS

- **Phase I - OSAMS specifies all interfaces invoked by models**
  - Developers are required to implement the interfaces themselves within their own simulation engines (dependence on standalone utility libraries are ok)
  - Could support interface subsets as long as there exists at least one available simulation engine that supports all interfaces
- **Phase II - OSAMS provides common middleware software infrastructure with the right programming hooks to allow any simulation engine to implement the mapping**
  - Can significantly reduce costs of making a simulation engine OSAMS compliant
  - Requires development of the middleware capability
  - Potential technical issues involving the mapping
- **Phase III - OSAMS encourages the development of freely available open source compliant simulation engines**
  - Consolidates development costs, but has potential problems involving software rights, CM, industry buy-in, life cycle support, etc.

Summary & Conclusions

- **Open Standard Architecture for Modeling & Simulation (OSAMS) is needed to lower the cost of M&S for CBD Overarching Models**
  - ✓ Strategy is not to just do things better… we must do things differently

In particular, reuse must begin at the model level

- **This will lower costs of model development, VV&A, scenario generation, operation of simulation, post processing**
- **Better performance without compromising fidelity can be achieved by composing tightly interacting models together into a single executing process**
- **Next-generation capabilities can be achieved without throwing away investments in legacy simulations or M&S technology efforts**

Final Thoughts

- **OSAMS is a proposed SOA for the M&S Community and is based on proven technology and freely available open source software that could be used today**

- **OSAMS Specifically Addresses:**
  - **Plug and Play interoperability/composability of Models**
  - **Interoperability of Simulations**

A Comprehensive Methodology for Evaluating the Effectiveness of CBRN Protection Systems

Presented to CBIS

January, 2007

Steven S. Streetman

ENSCO, Inc.

Overview

- CBRN System Evaluation
  - Current Practice
  - Gaps
- System Modeling
  - Effectiveness
  - Knowledge Structure
  - Costs
  - Response Criteria
- Integrated Biological Architecture Analysis

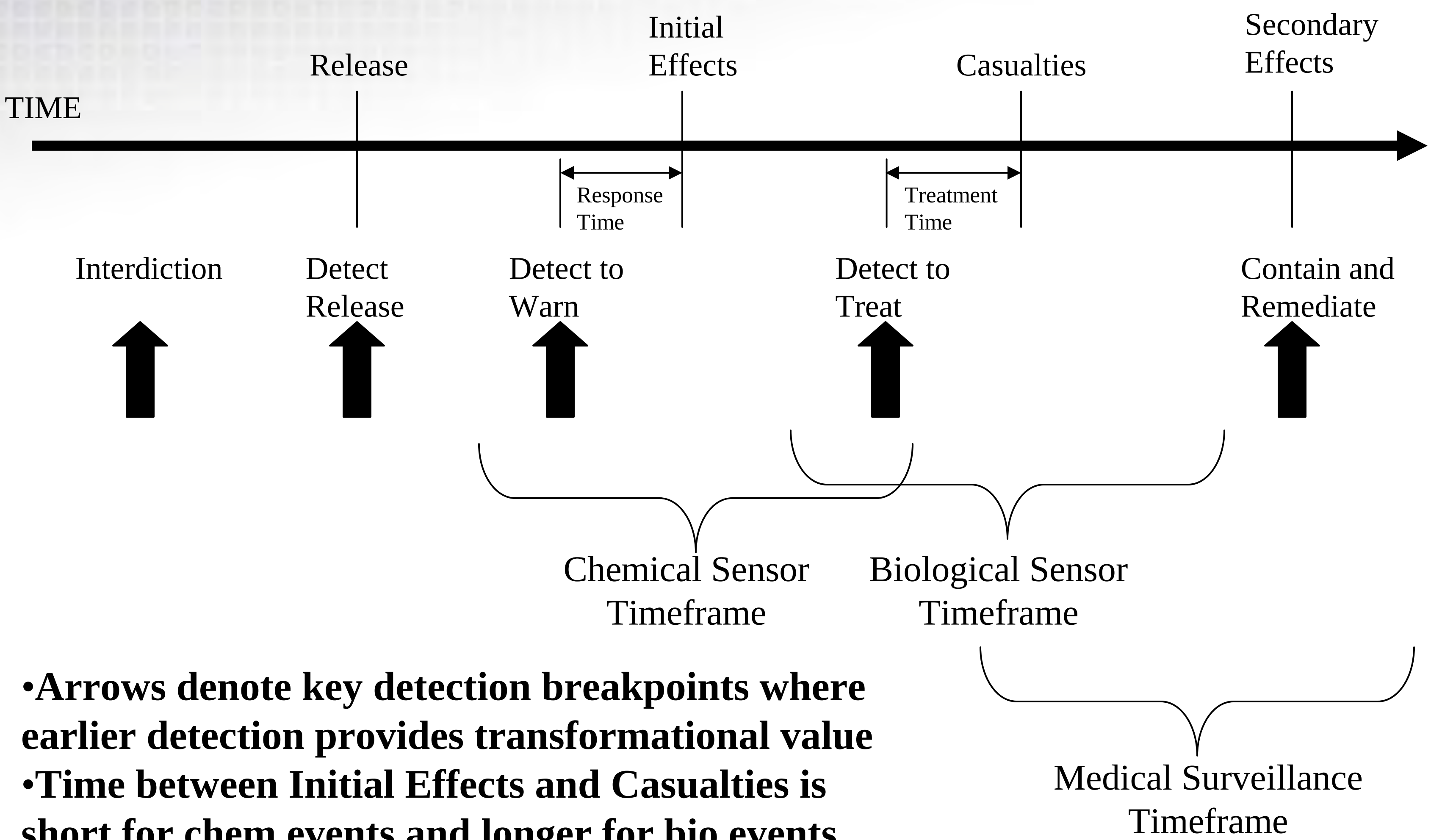
Key Questions

- How much protection is provided against a CBRN incident by a particular CBRN protection architecture?
- What is best value in improving existing CBRN protection architectures?

Current Practice

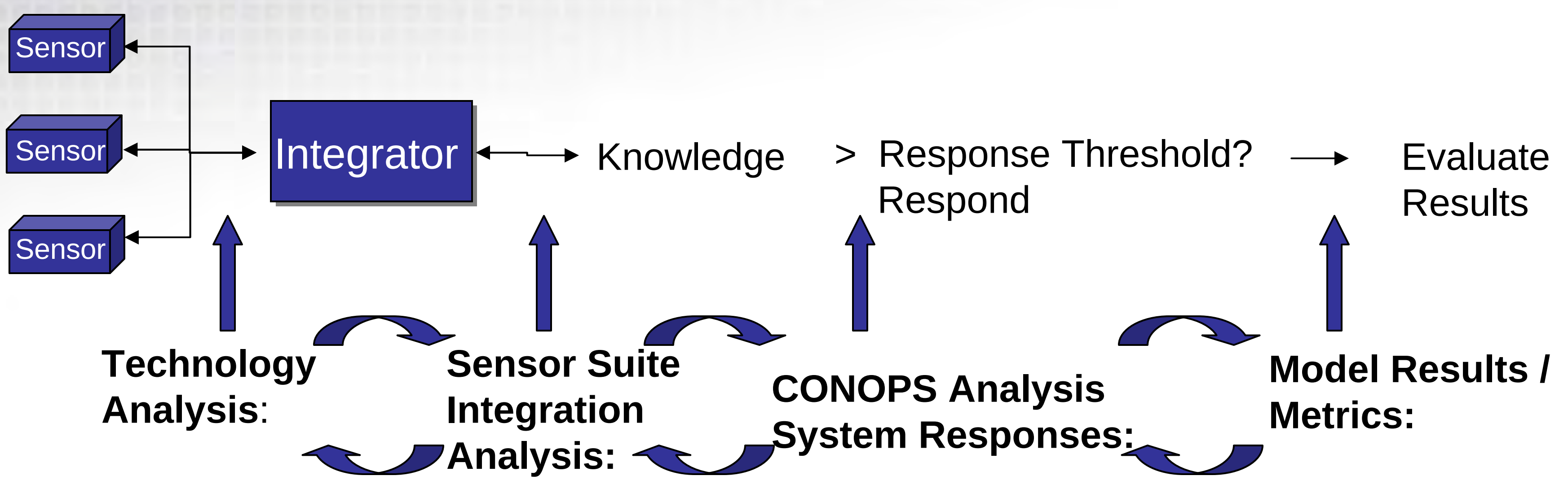
- Typical approach is to analyze sensor placement
  - If plume > sensor threshold at sensor location, sensor detects (success; base protected)
  - Most approaches iterate over possible release locations to determine P(detection) over the range of scenarios
- Gaps in typical approach
  - Protection is only provided if effective response is performed in sufficient time. Typical approach ignores responses and time to respond.
  - Unlikely in any operational deployment for high regret response based solely on sensor detection. Typical approach ignores alarm validation requirement and time to perform.
  - Cost of system is driven by false alarms not detection of real release. Typical approach only looks at sensor response to release, not system response in a typical operational envorinment. Typical approach calculates cost by cost to purchase and deploy sensors.

Sensor Event Timeline



- **Arrows denote key detection breakpoints where earlier detection provides transformational value**
- **Time between Initial Effects and Casualties is short for chem events and longer for bio events**

Example Breakpoint Analysis Process



Bio vs. non-Bio; chem ID; gamma counts	Suspect Event	Low Impact Response	•Estimated Casualties given response •Amount of area contaminated •Time to restore operations •Cost –Restoration –Economic Impact of Event
Bio ID; Multiple sensor detects; Rad Isotope	Probable Event	Serous Impact Response	
Lab tests; Video validation; Explosion Detection	Confirmed Event	High Regret Response	

IPP Bio Knowledge Architectures

Architecture	Knowledge Structure	Implemen-tation	Key Responses	Advantage: critical personnel	Advantage: all personnel
Current: no sensor	No detection; ID when symptoms appear	Medical examinations	•Treatment after symptoms	None	None
Baseline: Periodic ID	No detection; ID attempted every 24 hours using PCR (confirmed)	DFU collection; lab processing once per day	•Provide treatment (antibiotics) •Passive Collective Protection	Treatment prior to symptoms; COLPRO limits exposure	Treatment prior to symptoms
Triggered ID	Detect when agent at facility (suspect); triggers PCR analysis (confirmed)	Point bio detector (BAWS) with auto-PCR	•Lockdown on confirmation @30min after event	Lockdown prevents personnel exposure upon exit	Warning to avoid area; earlier treatment
Standoff +point ID	Detect prior to exposure (suspect); triggers PCR analysis (confirmed)	Standoff Bio (LIDAR) with auto-PCR	•Lockdown on confirmation @30min after event	Target remediation of affected area	HVAC control possible for non-critical areas
Standoff ID	Detect and ID prior to exposure (confirmed)	Standoff Bio LIDAR + IR Taggent	•Lockdown *prior* to event exposure	Earlier lockdown prevents exposure to personnel in facility	Earlier warning allows shelter in place
Standoff Neutralization	Detection and ID prior to exposure + neutralization	Standoff Bio LIDAR + IR Taggent + sufficient laser power	•Standoff neutralization of agent cloud	Exposure prevented	Exposure prevented to most personnel

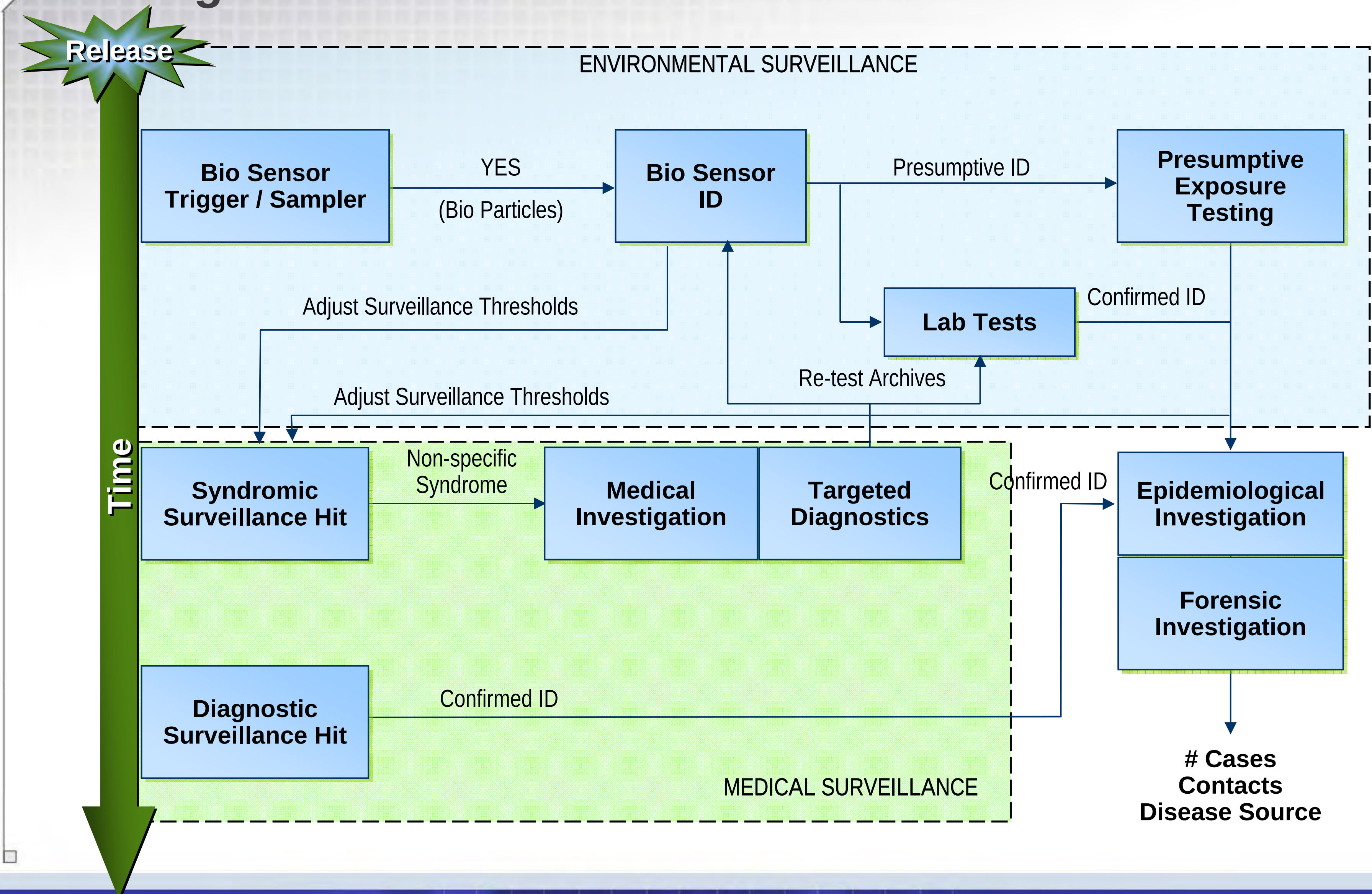
IPP Bio Knowledge Architecture Costs

Architecture	Implemen-tation	Estimated Cost	Cost Assumptions
Current: no sensor	Medical examinations	No Cost	Only costs to implement detection considered
Baseline: Periodic ID	DFU collection; lab processing once per day	•@$150/test → $30k/yr. •HEPA Filters for ColPro → $2,500 / facility	Assume tests will become cheaper as more are done
Triggered ID	Point bio detector (BAWS) with auto-PCR	•@$150/PCR test with 3-4 tests per day → $100k/yr. •Trigger sensor → $50k •ColPro as above	Assume advanced trigger algorithms reduce number of tests; also decrease in cost per test
Standoff + point ID	Standoff Bio (LIDAR) with auto-PCR	•Same PCR as above, same false alarms •Trigger sensor → $250k	Assume reduction in trigger sensor cost over time to $150k
Standoff ID	Standoff Bio LIDAR + IR Taggent	•IR Taggent → $300k •Trigger sensor as above	O&M of taggent consumables + delivery vehicle
Standoff Neutralization	Standoff Bio LIDAR + IR Taggent + sufficient laser power for decon	•Equivalent to Standoff Id costs since sensor re-used for neutralization (??? prob need separate laser for decon)	Additional power costs are small compared to overall cost

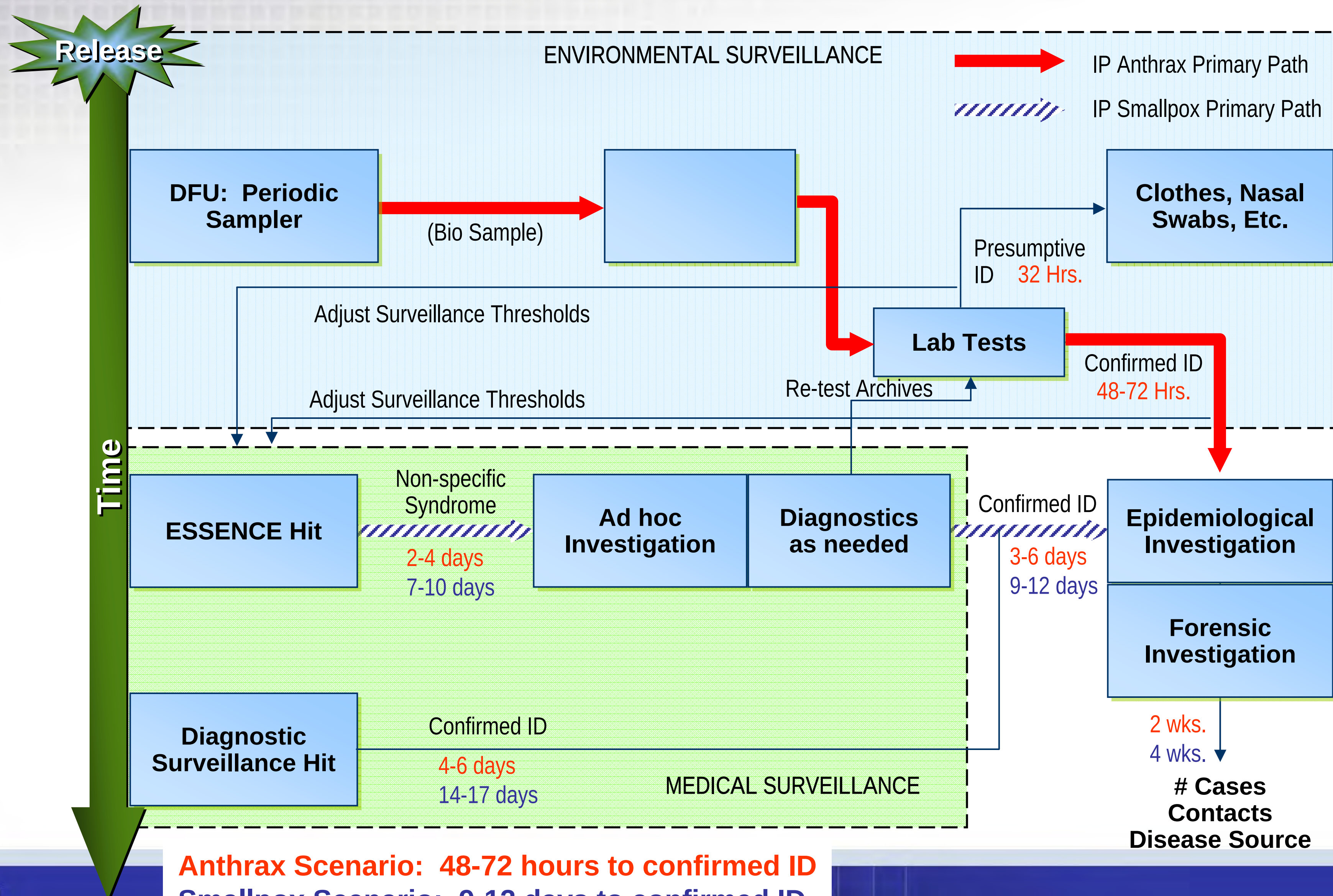
Response Table Example

RESPONSE	INFO REQUIRED	RELIABILITY REQUIRED	EXPECTED RESULTS	OBSERVABLES
Arrest and seize	1.Attack is planned. 2.Location of attackers/agent prior to attack.	Suspect (provided there are manageable suspect alarms).	Threat stopped with no ill effects.	•Attacker comms •Release equipment (sprayer)
Stop release	1.Attack is underway. 2.Location of attack.	Suspect (can usually investigate and evaluate)	Less agent released	1.Spraying
Shelter in place	1.Attack has occurred 2.Facility is in the agent's path	Suspect – HVAC control. Probable – restrict movement	Filtering reduces exposure *while inside the building.*	1.Agent itself before inside exposure
Don IPE	1.Attack has occurred 2.Facility is in agent's path 3.Type of agent	Probable – Confirmed	IPE reduces exposure until they can get to safe area	1.Agent itself before exposure
Personal decon	•Person has been exposed to agent •Type of agent	Probable – Confirmed	Decon reduces exposure of personnel	1.Agent itself before or after exposure
Area decon	1.Attack has occurred 2.Specific agent 3.Area Affected	Confirmed	Area decon reduces illness from re-aerosolization	•Agent itself (surface) •Agent effects (illnesses)
Treatment (CIPRO)	•Attack has occurred •Specific Agent •Person likely infected	Confirmed	Prevents death; reduces illness	1.Agent itself 2.Agent effects (to treat secondary infections)
Neutralization	•Attack has occurred •Cloud Location	Confirmed	Prevents exposure	1.Agent itself

Integrated Bio Surveillance Architecture

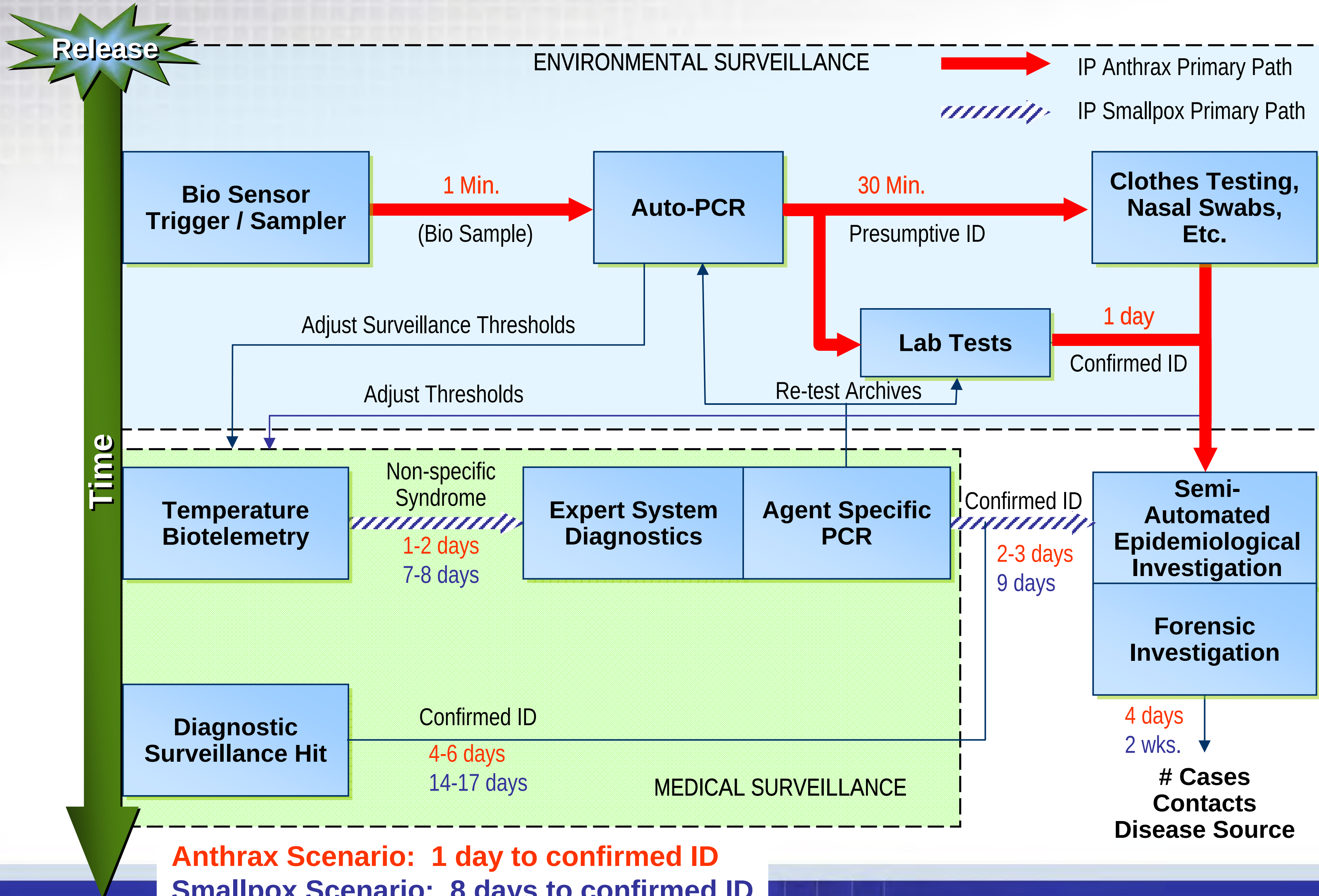


Current Bio Surveillance Architecture



Anthrax Scenario: 48-72 hours to confirmed ID
Smallpox Scenario: 9-12 days to confirmed ID

Potential Bio Surveillance Architecture



Anthrax Scenario: 1 day to confirmed ID
Smallpox Scenario: 8 days to confirmed ID

Joint Effects Model (JEM)
Briefing to CBIS

January 2007

Tom Smith
JEM Acquisition Program Manager
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JEM Program Office Org Chart

Tom Smith
JEM APM

Dan Hallock
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LT Curt Wall
Inc 2 DAPM

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CDR Stephanie Hamilton
Rick Fry

Architecture Lead: Andy Hill
Product Support: Gerald Slonaker
Test Lead: Marcus Fieger

Program Support:
Susan Sullivan
Eric Rial

PMO Engineering Support:
Ralph Nebiker, Lead
Kristin Baird

Software Development
Lead: Steve Twyman
Northrop-Grumman

NSWC Dahlgren: Matt Wolski
Preon Moore
L-3 Titan (JSTO): Ian Sykes
IEM: Serge Olszanskyj
Steven Stage

T&E IPT Lead: Russell Brown
Accreditation Agent: Mike Metz
IV&V Lead: Brian Boyle

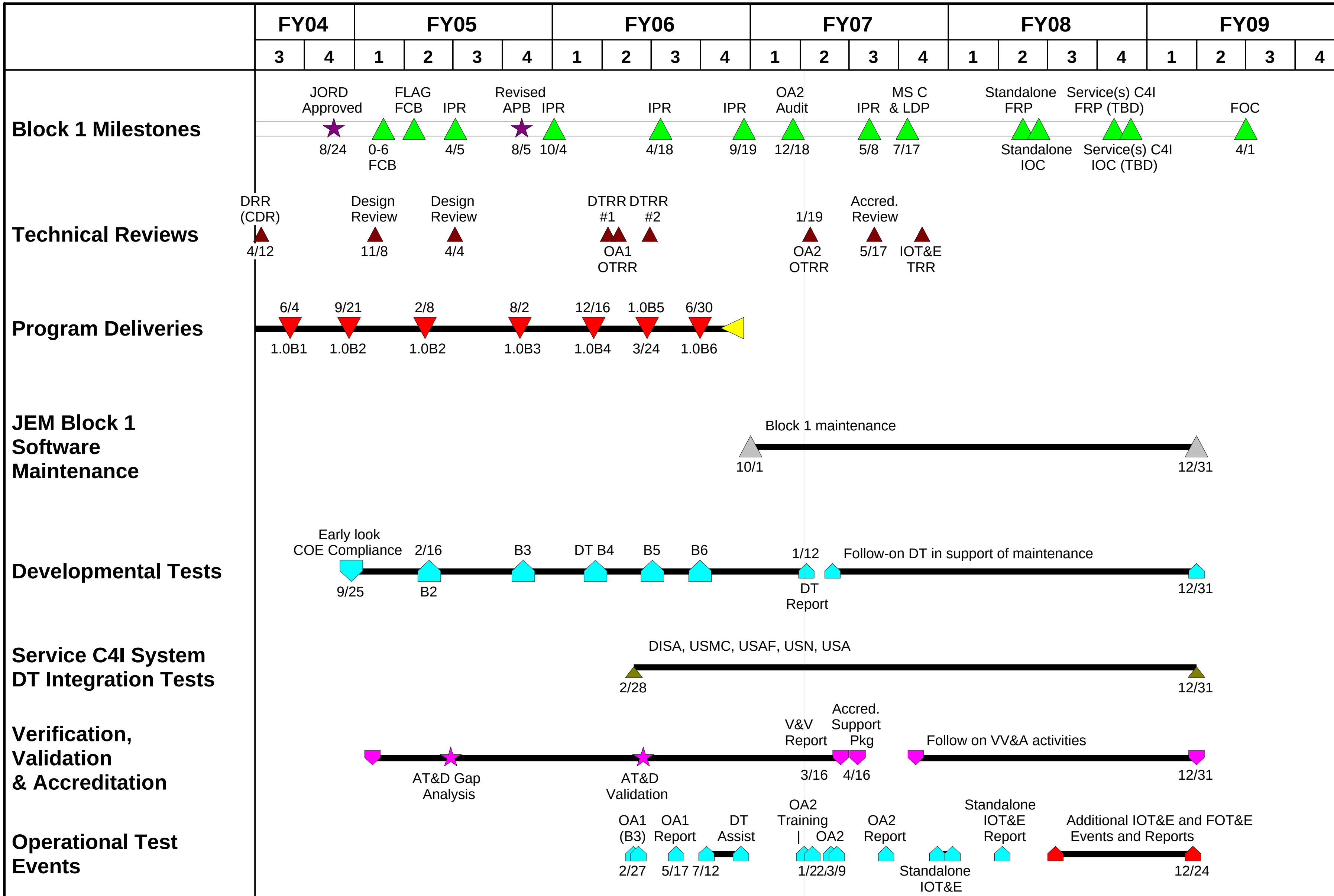
Description

- JEM is an ACAT III Program that will provide a single, validated capability to predict the transport and dispersion of Chemical, Biological, Radiological and Nuclear/Toxic Industrial Hazard events and their effects
- JEM will be accredited for all uses currently supported by the three interim accredited DoD S&T Hazard Prediction Models
- JEM will be integrated with Joint and Service Command & Control Systems and will also be available as Standalone

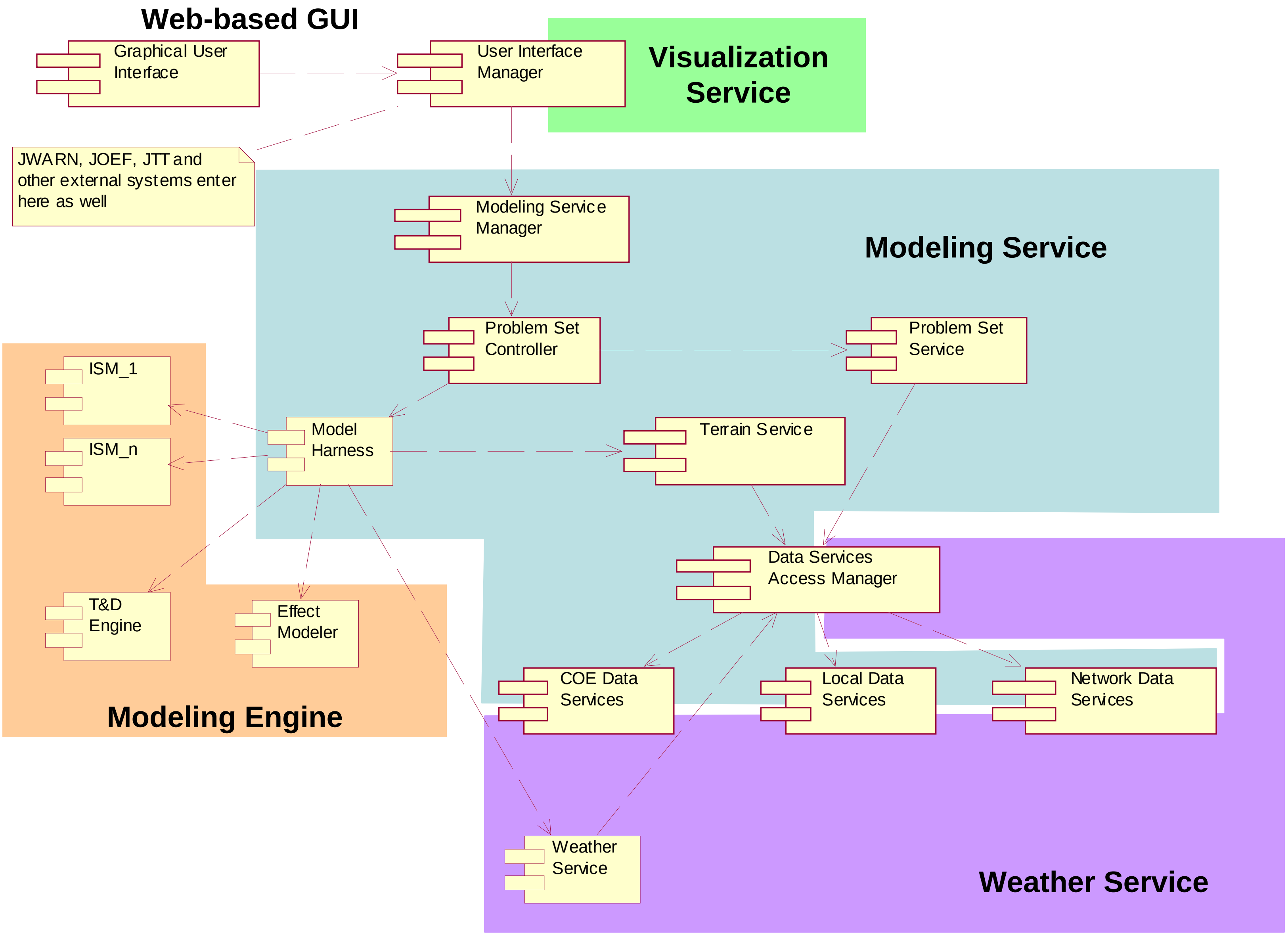
Core Capabilities

- Transitions HPAC, VLSTRACK, and D2PUFF technologies, and baselines the DoD hazard prediction capability
- Supports multiple deployment strategies
  - Operates on both UNIX and Windows operating systems
  - Common Operational Environment (COE) / Network Centric Enterprise Services (NCES) / GIG / Service C2 systems
  - Standalone, Networked, Distributed, or Web access
- Provides high fidelity hazard predictions to:
  - Joint Warning and Reporting Network (JWARN)
  - Joint Operational Effects Federation (JOEF)
  - Any system calling the JEM Web Services Interface
- Interoperates with meteorological data systems
  - Virtual Natural Environment Net Centric Services (VNE-NCS), METOC Data Service (MDS), Integrated Meteorological System (IMETS), Joint Weather Impact System (JWIS), and others

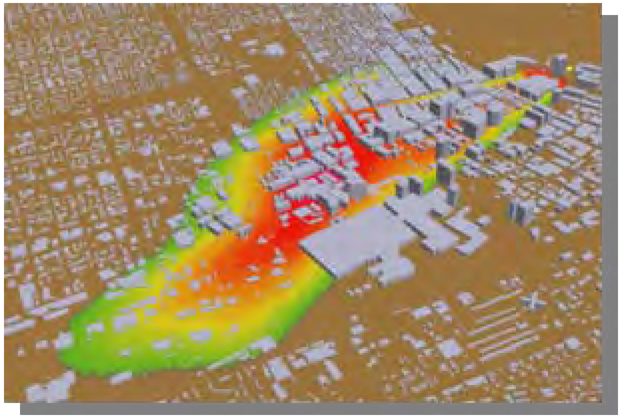
JEM Increment 1 Schedule



Service Oriented Architecture (SOA)



JEM Increment 2



- **Technologies for Increment 2:**
  - Urban Modeling
  - Littoral/Coastal Effects Modeling
  - Missile Intercept Hazard Prediction
  - 10% Improvement in Speed & Accuracy of JEM Baseline
  - Source Term Estimation (Backtracking)
    - Uses data gathered from sensors
      - Estimate source term
      - Refine hazard prediction
    - Includes processing of sensor data received from JWARN
  - Calculate initial & delayed casualties and incapacitation for both civilian and military populations
  - Estimate effects from a 5,000 weapon strike in less than 90 minutes
  - Allow user to modify input parameters to accommodate population migrations

JEM Increment 2 Way-Forward

- Complete fielding of Increment 1
- Work with JRO/SHAPE ICT on Capability Development Document (CDD) in preparation for Milestone C
- Conduct Analysis of Alternatives (AoA) – JCIDS
  - Work through JSTO for identification and assistance in identifying and selecting appropriate technologies
    - Model Integrated Product Team (IPT)
    - Technology Transfer Agreements (TTA)
- Identify Government Agencies with additional capability
  - Lawrence Livermore National Laboratory (LLNL)
  - Missile Defense Agency (MDA)
  - Service research laboratories
- Issue Broad Agency Announcement (BAA) to fill gaps not covered by JSTO sponsored technologies
- Design, develop, test software FY08-FY10

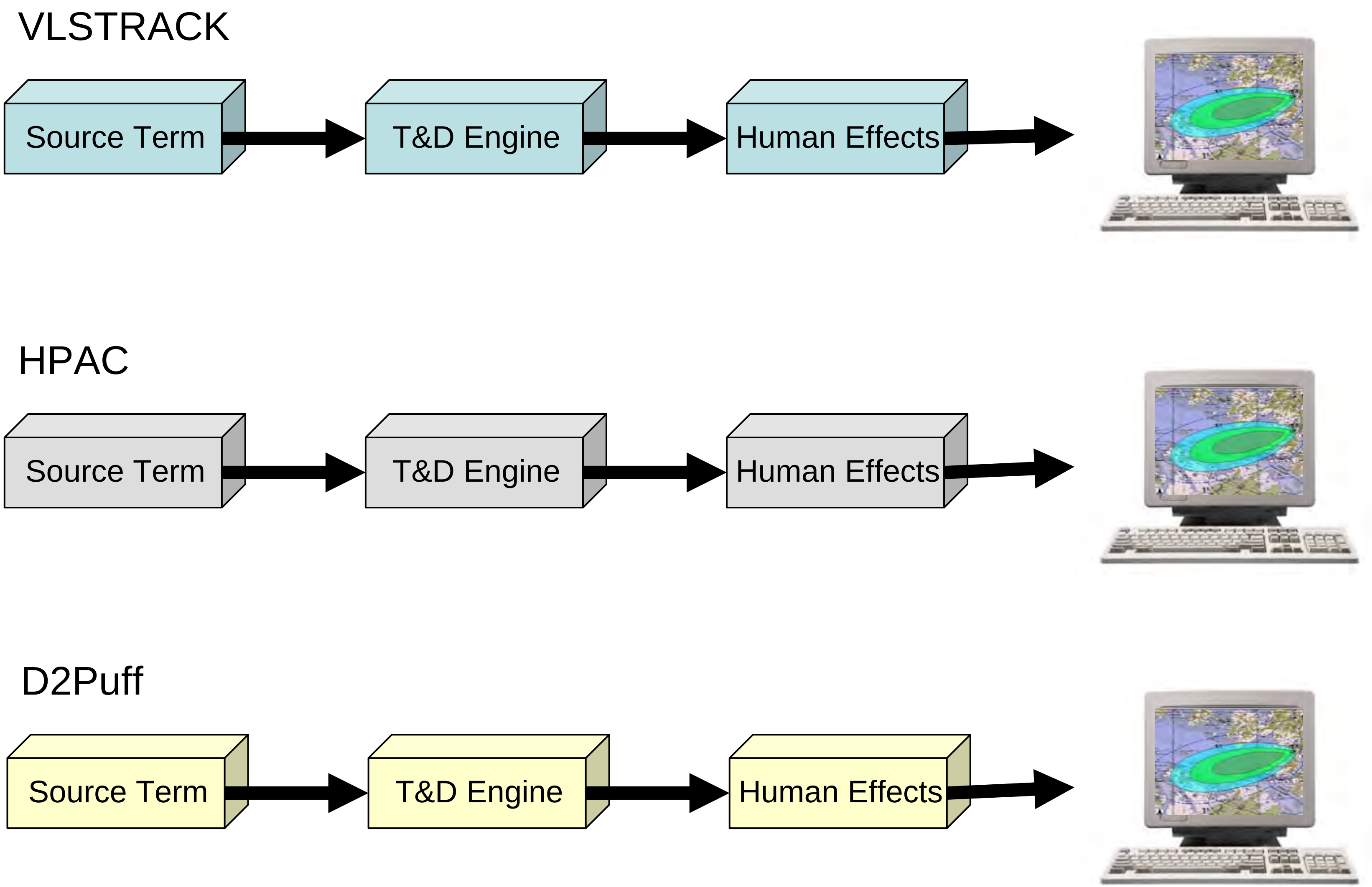
Increment 3 Requirements

- Waterborne Hazards
- Complex structures, Building interiors
- Human performance degradation
- Contagious/infectious diseases
- Effects on aircraft at various altitudes/ships underway

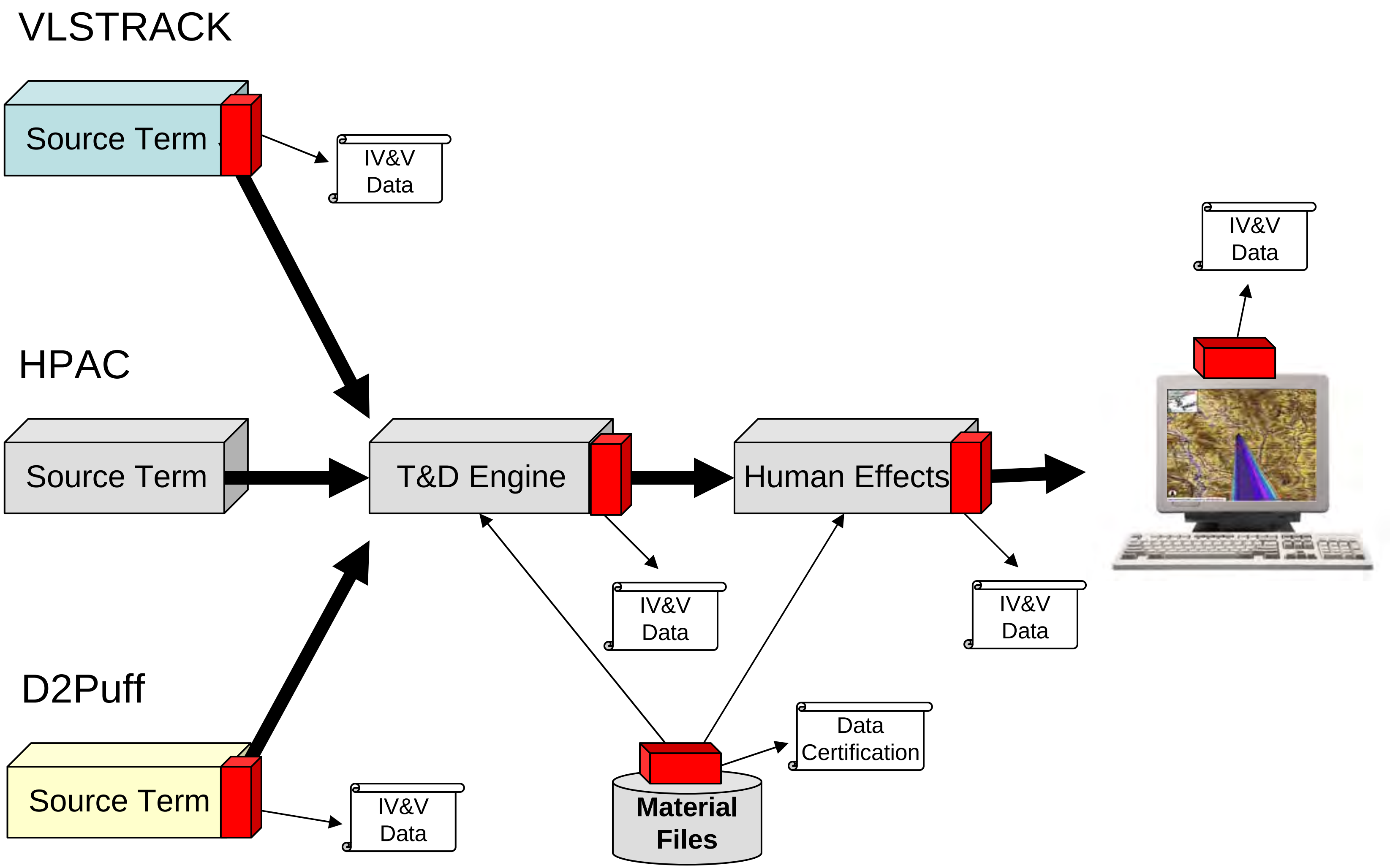
JEM Technology Challenges

- Performance of Service Oriented Architecture (SOA) applications on CPU & memory constrained systems
- Incorporating urban hazard modeling and other advanced modeling into SOA
  - JSTO/DSTL successfully implemented UDM into JEM
- Maturity of advanced modeling capability
  - Nature of S&T development programs
  - Reliable data for supporting model technologies
  - Demand for the next best thing…but what about Verification Validation and Accreditation (VV&A)?
- Diverse Joint and Service specific weather models
- Evolving Joint and Service C4I system baselines
- Combining multiple CBRN hazard models, maintaining the integrity of the core technologies, and proving it

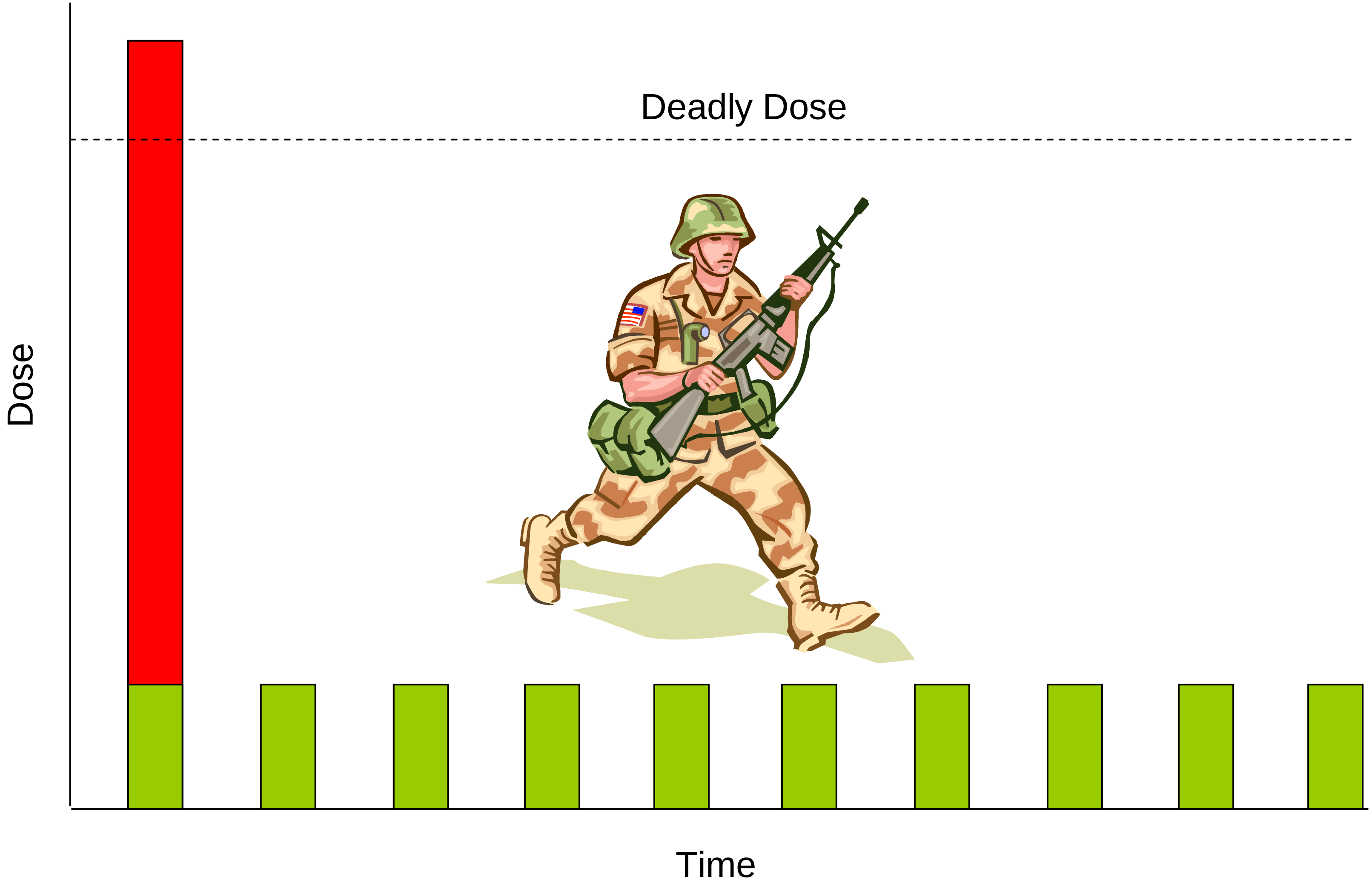
Pre-JEM Model Sequencing



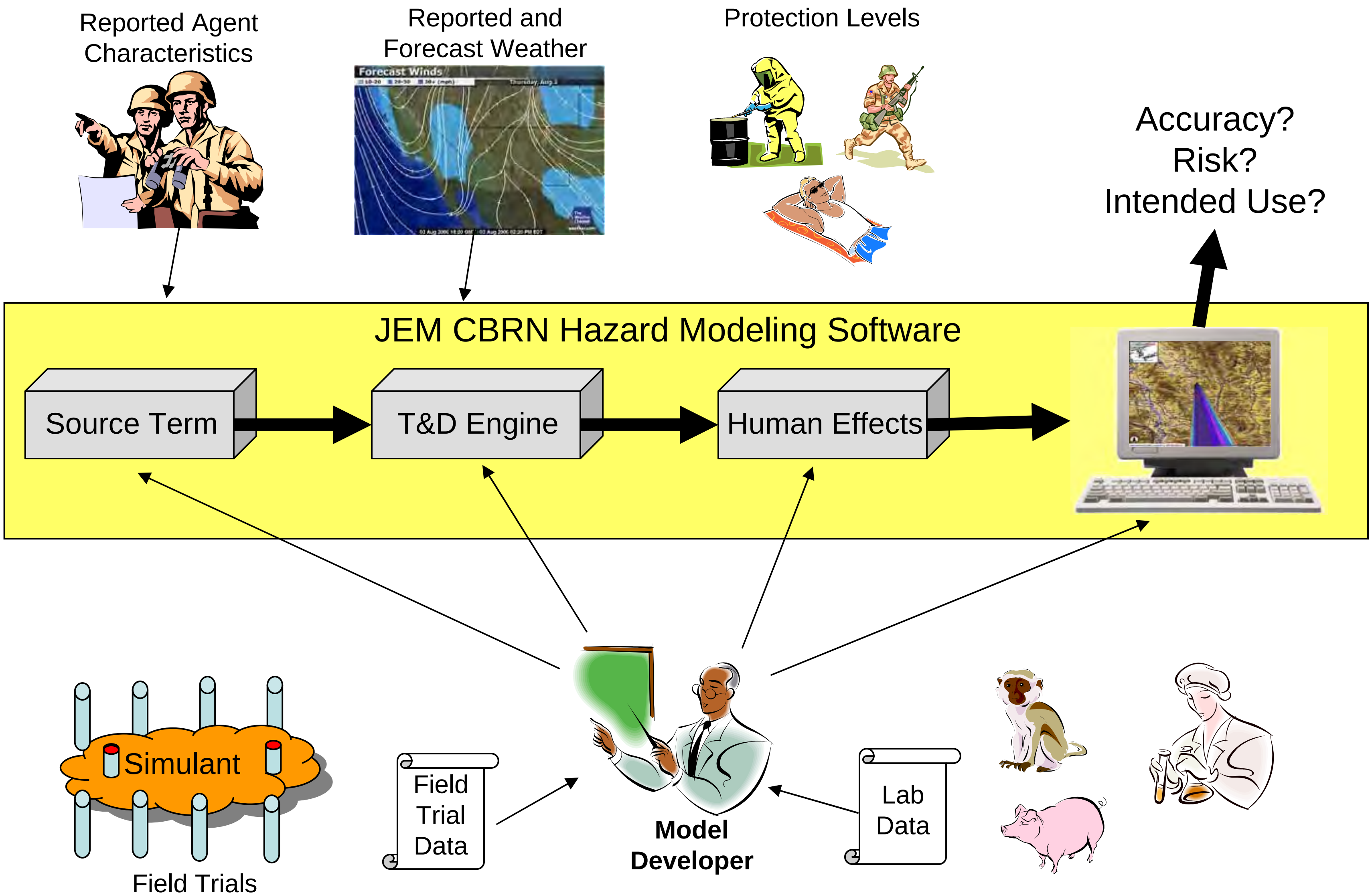
JEM IV&V Data Points



JEM Toxicity Factors – How do we model it?



JEM Accreditation Challenges



JEM Status

- Coordinating with JSTO on Increment 2 & 3 technologies
- Participating in International Task Force 49 (ITF-49) and Tech Panel 9 (TP-9) to increase interoperability between Canada, UK, US and other international partners
- Finalizing Increment 1 Verification, Validation and Accreditation (VV&A) activities for 3QFY07 review
- Preparing for Increment 1 Milestone C in 3QFY07
- Preparing for Standalone Operational Test in 4QFY07
- Continuing to work with Joint & Service C4I systems
- Preparing for Increment 2 Milestone B in 1QFY08

Business Opportunities

	Time Period
• Physical Science and Technology Broad Agency Announcement (BAA)	FY06 & FY07
– December each year	
– Other BAA solicitation occurs under the CBDIF program	
• SPAWAR Knowledge Superiority (BAA)	
– JPM IS Technology Challenges/S&T Gaps	Open Indefinitely
• JWARN	
– JCID production (RFP)	FY08 – FY12
– Block 2 Increment 1 Sustainment	FY08 and beyond
– Block 2 Increment 2 Design & Development	FY08 – FY09
• JEM	
– JEM Lead Integrator (SEAPORT E)	FY07-FY12
• Sustain Block I	
• Integrate S&T Capabilities for Block II & Beyond	
• JOEF	
– JSTO Technology Insertion Increment 1	FY06 – FY08
– JSTO Technology Insertion Increment 2	FY06 and beyond
– Software Development Increment 2 and beyond	FY08 and beyond

Questions?

NORTHROP GRUMMAN

DEFINING THE FUTURE

Programmable SDR

CBIS 2007

Chris Wasser

Technical Director

Northrop Grumman

Definition

- SDR
  - Software-defined Radio
  - “wireless communication in which the transmitter modulation is generated or defined by a computer, and the receiver uses a computer to recover the signal”*

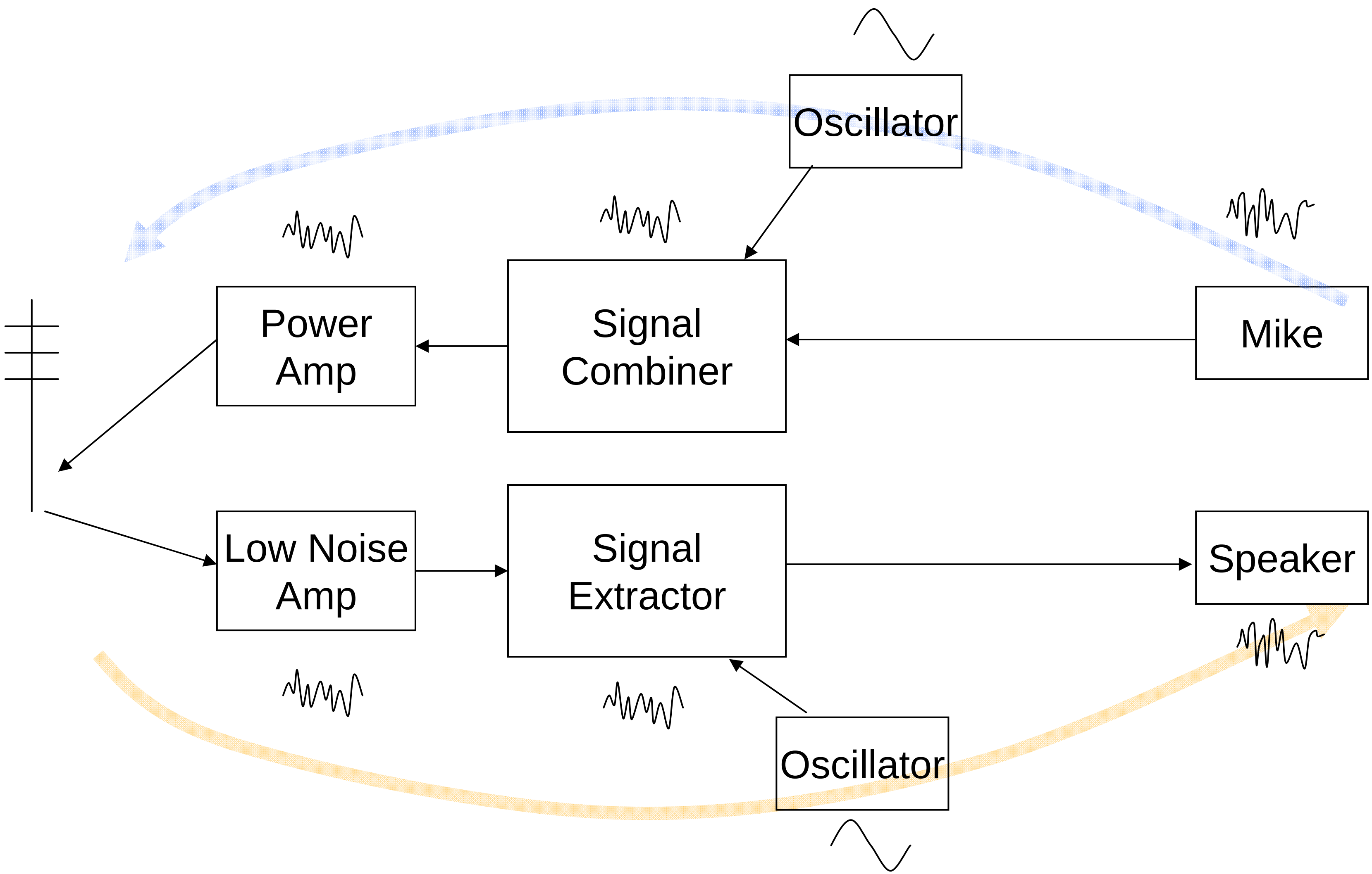
* http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci333184,00.html

Background

- Transmission of information (using Morse Code) via “wireless telegraphy” was developed by Guglielmo Marconi in 1895, although others had experimented with electricity and “spark-gap” transmission as much as 50 years prior.

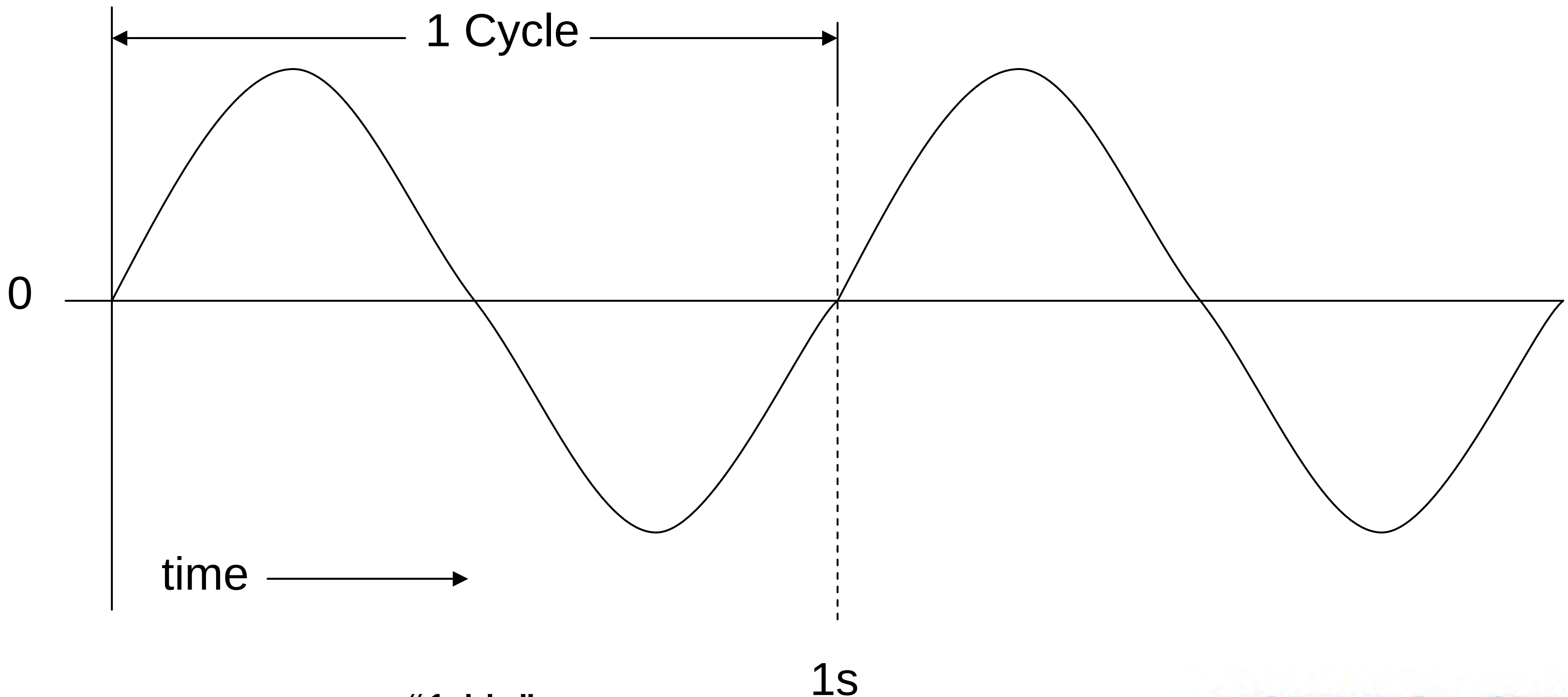
- To this day, radios provide essential communication to military forces the world over.

Radio Design



Radios

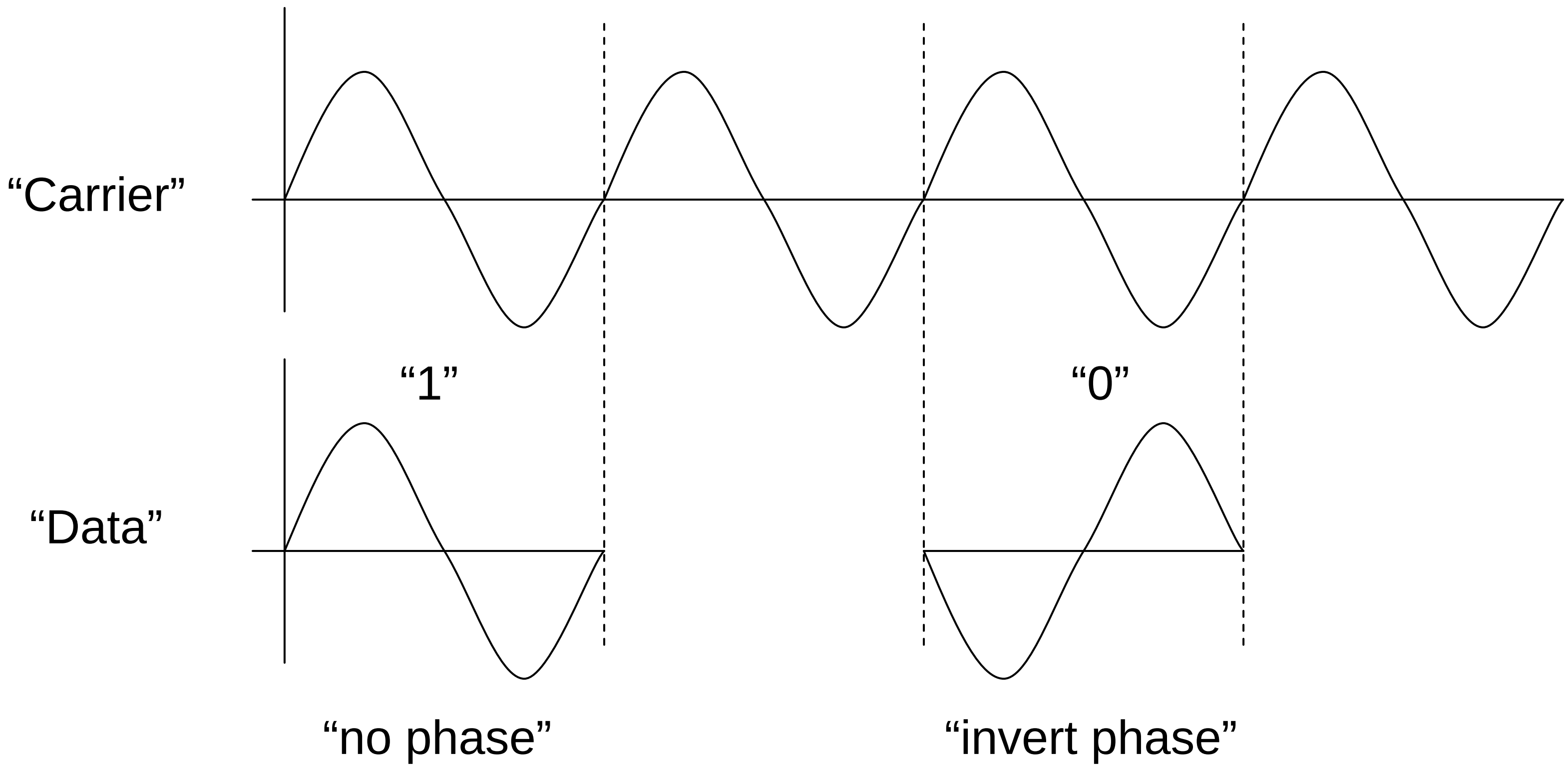
- How do they work?
  - Electro-magnetic (RF) energy creation
    - Sine wave



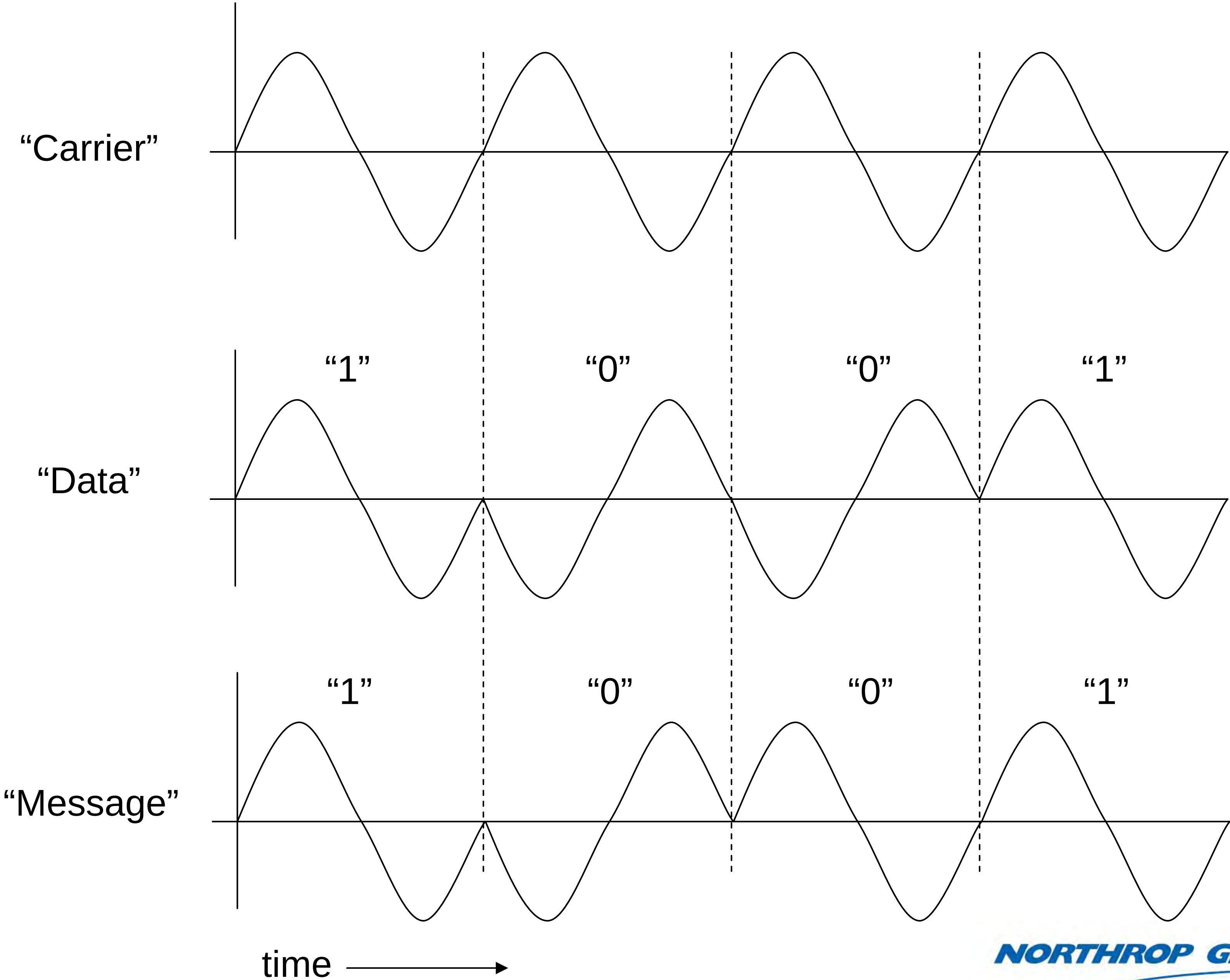
"1 Hz"

Radios (2)

- Manipulate the RF to carry information

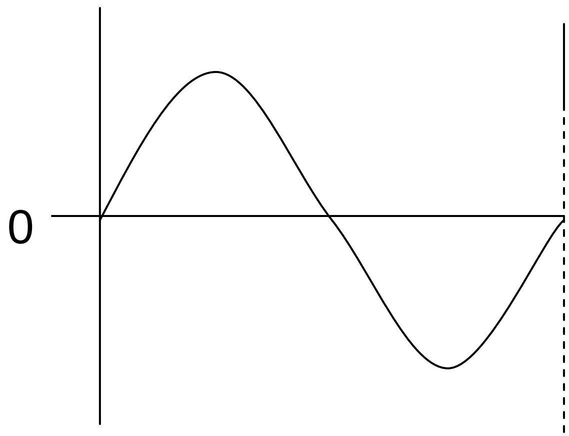


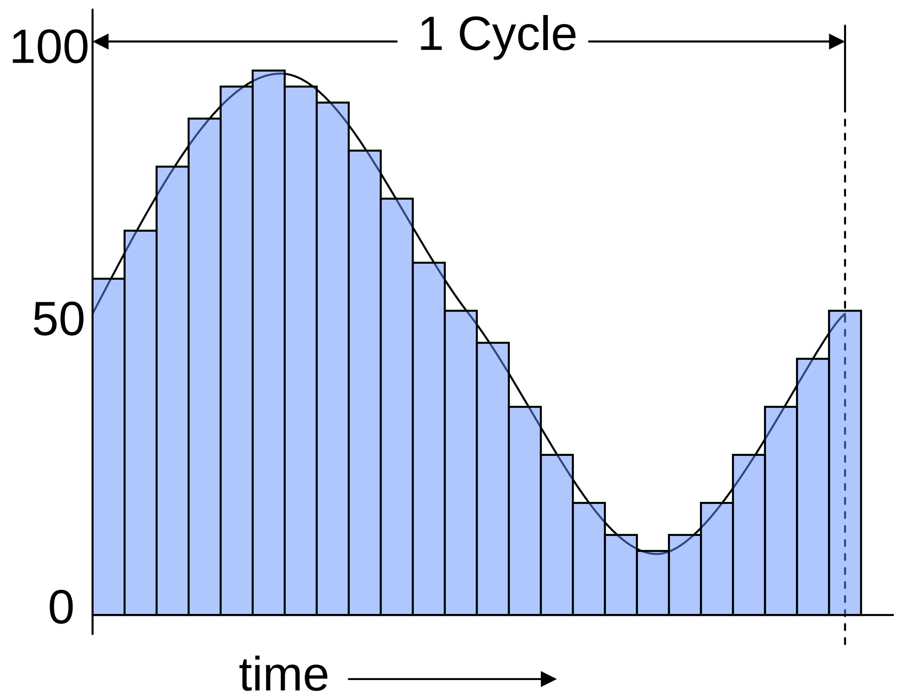
Radios (3)



Another Way to Create RF

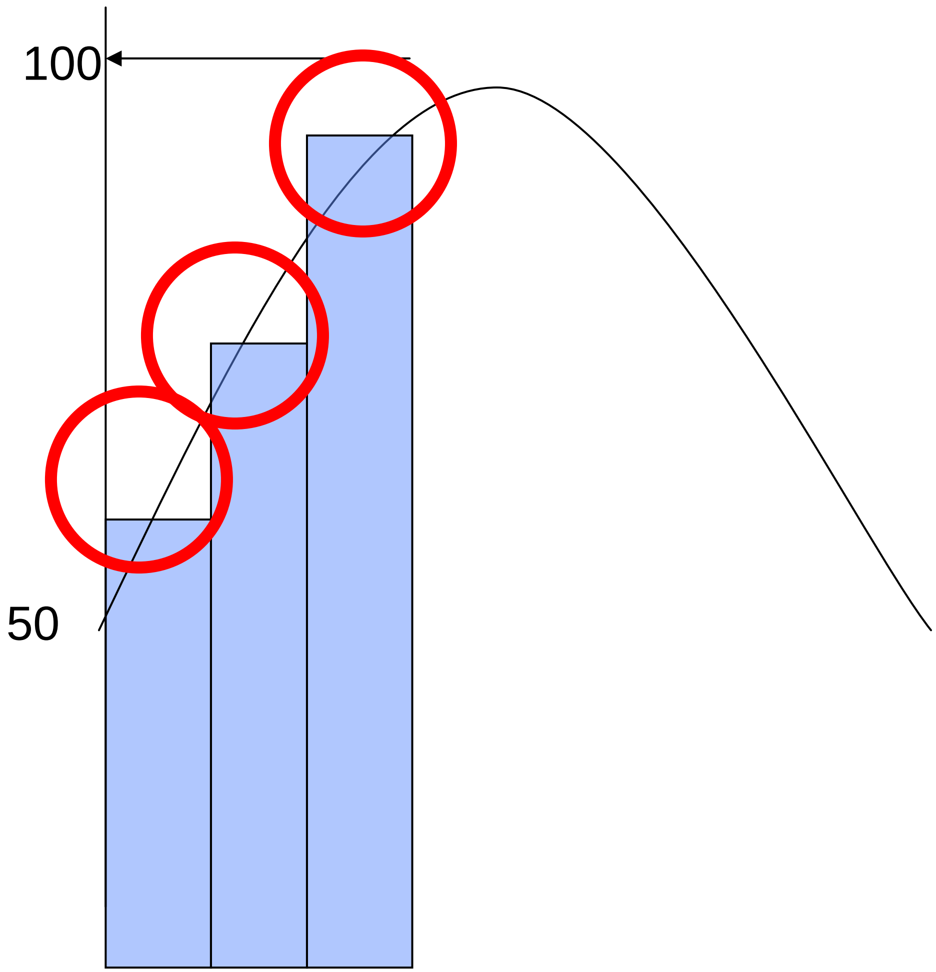
- create "sine wave" from scratch
  - approximate the shape using digital values
  - using a "Digital to Analog Converter" (DAC)



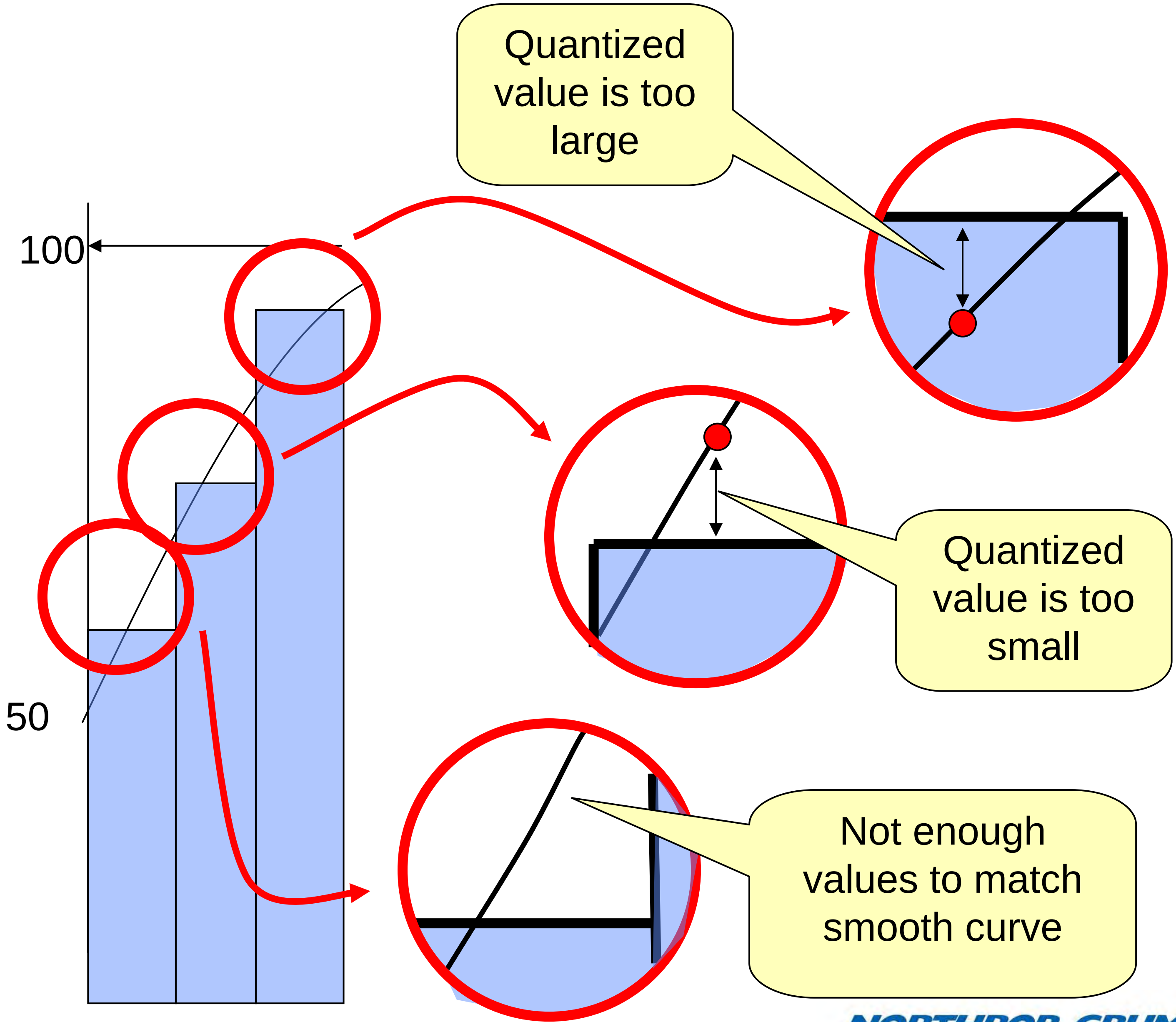


Some problems with the approximation

- Since the number values are “quantized”
  - rigid set of whole values (0, 1, 2, 3…)



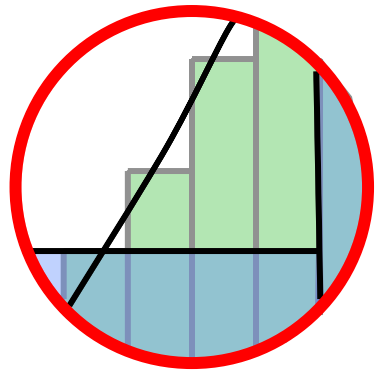
Some problems with the approximation (2)



What to do?

- Better quantization
  - "higher resolution"
    - More expensive

- More values
  - remember Calculus?
  - produce the values faster
    - Nyquist theorem* identifies the lower limit
    - 2B, or 2 x (bandwidth)



* http://en.wikipedia.org/wiki/Nyquist-Shannon_sampling_theorem

A Short Aside…

- We have to say it… JTRS
  - Joint Tactical Radio System
- Driving force behind SDR design and implementation
  - separate the protocol (waveform) from the hardware
- Design standard architecture
  - Software Communication Architecture (CA)
  - allows waveforms to be converted into RF signals
- Design of standard “waveforms”

Waveforms

- ISO OSI Layers 1-3
  - physical RF signals
  - data encoding schemes
    - low-level channel sharing
    - security, error detection/correction
  - networking
    - high-level channel sharing
    - Internet Protocol (IP)
    - Quality of Service (QoS)

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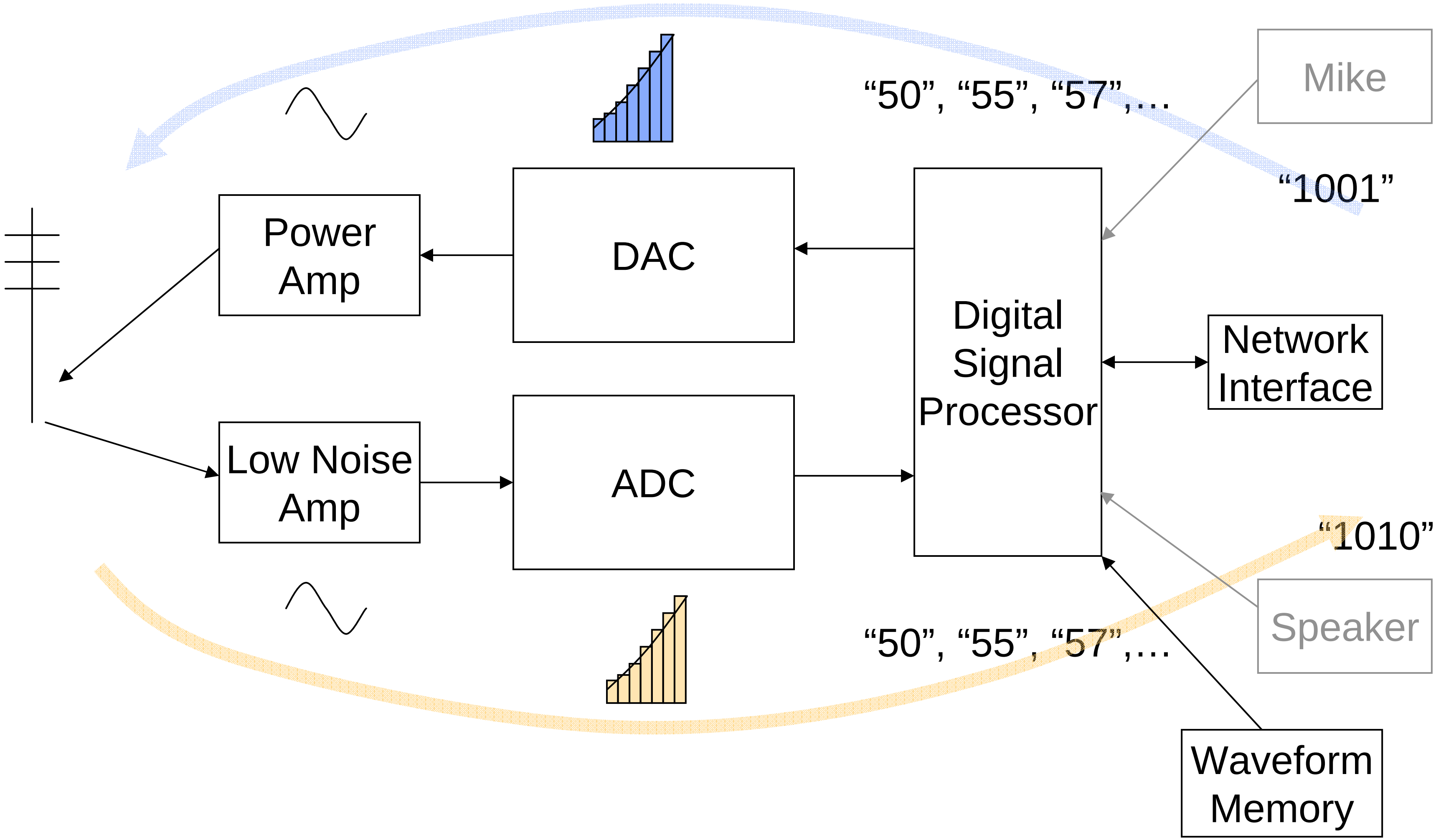
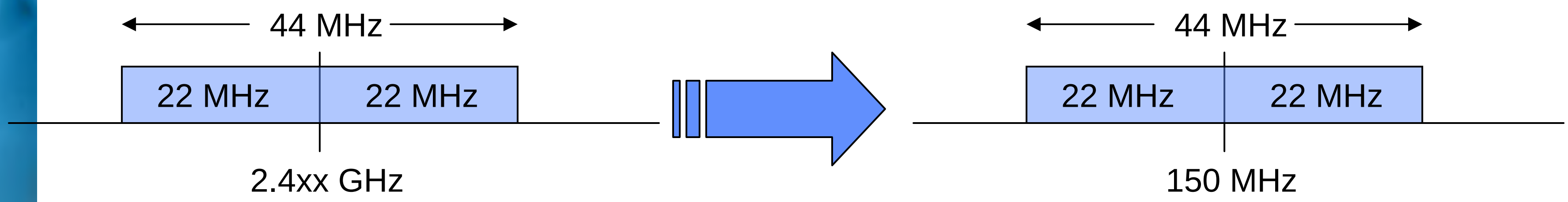
SDR Block Design

- hypothetical



Performance Example

- 802.11b
  - 2.4 GHz, 44MHz channel
    - in other words: data takes up only 44MHz



  - Nyquist rate = 2B = 2 * 44 MHz = 88 MHz sample rate

  - This leaves a LOT of CPU performance to spare!

Current Generation Hardware

- Xilinx Virtex-II Pro and Virtex 4 FX FPGAs have embedded 405 PowerPC processors
  - 400MHz,
  - FPGA implements signal processing instructions
- Intel Core2 Extreme
  - 2.93 GHz
  - High performance Math core
    - special signal processing instructions
- Texas Instruments TMS320C6x series
  - 1 GHz
  - special signal processing functions

CBRNE Design Example

- Current JCID design
  - CPU: Intel Xscale PXA255, 400MHz
  - Memory:
    - RAM: 256 MB
    - Flash: 128 MB
  - Embedded software: C++, ~16MB
    - Windows CE 5.0
  - Manages up to 4 sensors via serial (RS-232) or Ethernet
    - < 10% of the CPU (nominal)
  - Wireless (802.11b) mesh networking
    - separate subsystem

CBRNE Design Example (2)

- CPU:
  - Intel Xscale PXA255, 400MHz -> many choices
- Memory:
  - Most SDRs will have at least 256Mb for operation, plus non-volatile (flash) storage for waveforms
- Windows CE 5.0
  - possibly need to port S/W to another OS
    - likely Linux running “on top” of the SDR’s OS
- Serial (RS-232) or Ethernet
  - many JTRS SDRs will have Ethernet to support net-centric data comms
  - Serial is another matter… but chips are cheap
- Wireless mesh networking
  - part of the “waveform” design

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Considerations

- Design issues include:
  - Different, possible “non typical” CPUs
    - PowerPC, embedded ARM, etc.
  - Real-time Operating Systems (RTOS)
    - as opposed to Windows or Linux
      - but there are options…
  - Power and heat
    - fast, powerful CPUs turn lots of electrons into lots of heat

CPUs

- Most current Sensor management software is either C, C++ or Java
  - PowerPC
    - GNU "gcc" compiler available
    - Java Virtual Machine (JVM) available
  - ARM
    - GNU "gcc" compiler available
    - Java Virtual Machine (JVM) available
  - Note on the JVM:
    - be wary of how much resources these take up
    - specialty versions
      - but watch for missing features

Operating Systems

- Most current Sensor management software is either Windows, WindowsCE or Linux
  - Windows / WindowsCE
    - NOT available for PowerPC
    - but WindowsCE is available for ARM
  - Linux
    - Both PowerPC and ARM available
      - as well as for many others…
  - Watch out for resource needs for OS over RTOS

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Some Other Gotchas

- There are some “gotchas”
  - embedded devices tend to have “quirks”
    - limited memory
    - no support for virtual memory
    - special instructions to access Signal Processing features
  - Current SDR designs
    - have limited external connections
      - limited (or no) Ethernet
      - limited (or no) Serial port support
    - power hungry

Network Interaction

- Keep in mind that the application software is competing with the SDR software
  - SDR
    - low latency, high CPU demand, bursty
  - Application
    - moderate latency, moderate CPU demand, more regular
  - Watch out for applications that are:
    - Low latency
      - sensor management…
    - high CPU demand
      - M&S is probably a bad idea…

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Conclusion

- SDRs will provide a ubiquitous computer platform across the military
- "Excess" capacity can be exploited
- Issues:
  - unique computing environment
    - RTOS, latency, specialty CPUs, odd form factors
- SDRs provide an excellent opportunity for embedding Force Protection capabilities with the forces we are protecting.

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DEFINING THE FUTURE

Questions?

Next Generation Computational Chemistry Tools to Predict Toxicity of CWAs

William (Bill) Welsh

welshwj@umdnj.edu

Prospective Funding by DTRA / JSTO-CBD

ebCTC environmental bioinformatics and Computational Toxicology Center

A State-wide, Regional and National Resource

< www.ebCTC.org >

Funded with support from the U.S. EPA

Consortium Members

UMDNJ
ROBERT WOOD JOHNSON MEDICAL SCHOOL
University of Medicine & Dentistry of New Jersey

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

FDA U.S. Food and Drug Administration
Center for Toxicoinformatics, NCTR

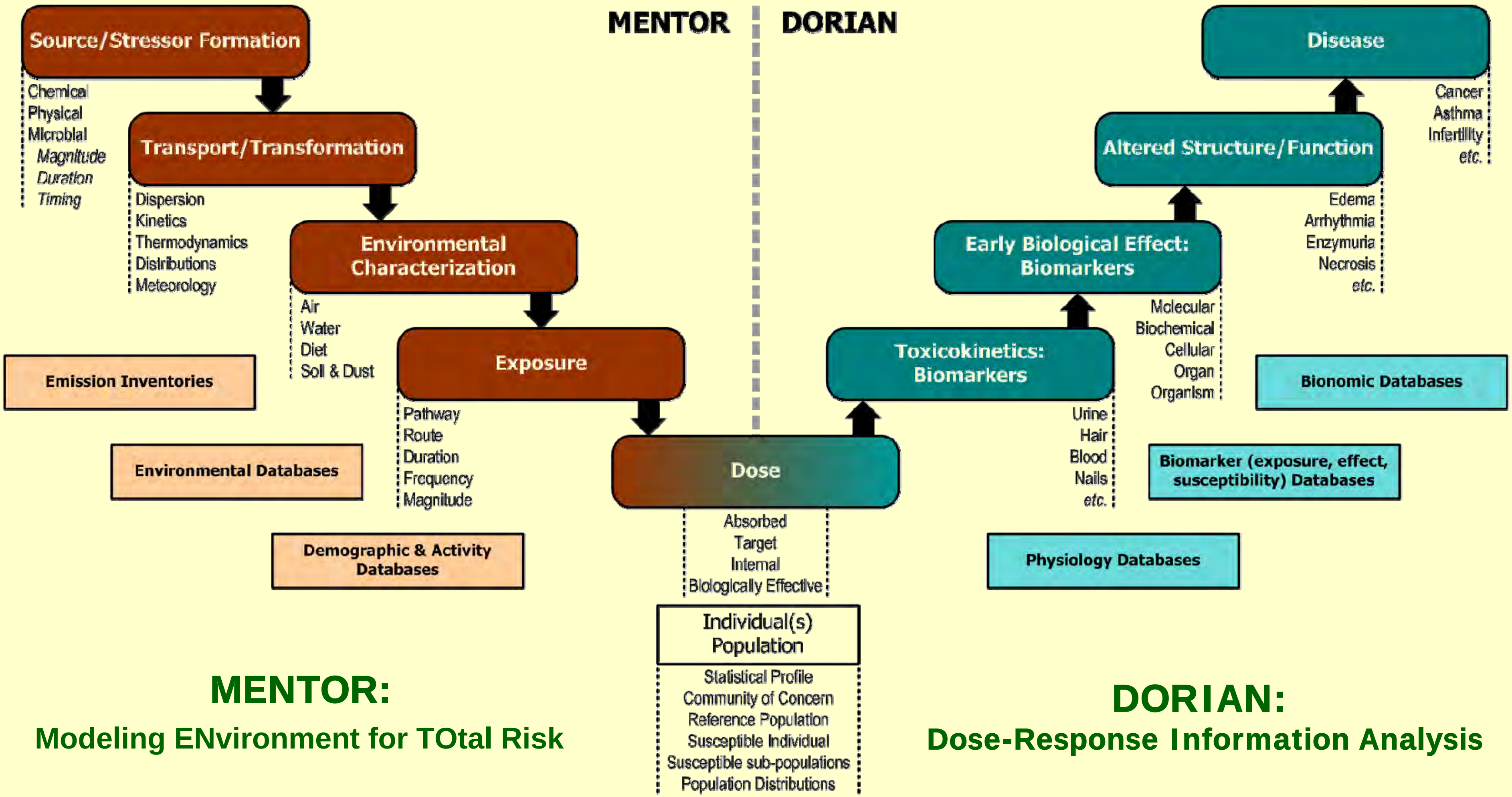
Princeton University

Major Research Thrusts

- MENTOR-DORIAN Computational Toxicology System that spans the Source->Dose->Outcome continuum
- The Environmental Bioinformatics Knowledge Base (ebKB: www.ebCTC.org)
- *ArrayTrack*: toxicological bioinformatics platform to process genomics, proteomics and metabonomics data
- Hepatocyte Metabolic Model for Xenobiotics
- **ChemTox, a suite of chem-informatics tools for toxicant identification & characterization**

MENTOR & DORIAN

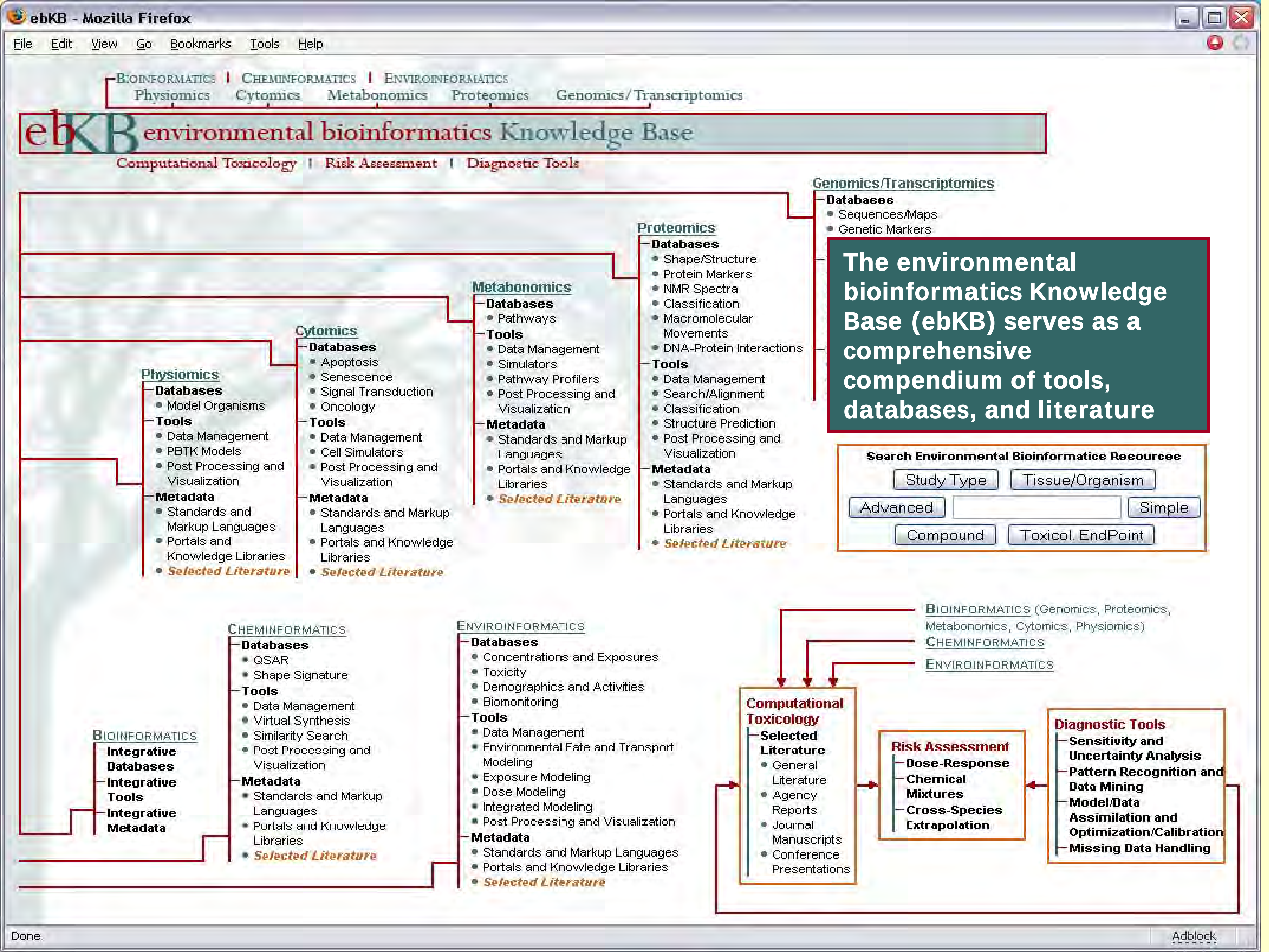
Address the Source-to-Outcome Continuum



MENTOR:
Modeling ENvironment for TOtal Risk

DORIAN:
Dose-Response Information Analysis

Adapted from chart by R. Calderon, USEPA/NHEERL, 2003


ebKB - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
BIOINFORMATICS | CHEMINFORMATICS | ENVIROINFORMATICS
Physiomics Cytomics Metabonomics Proteomics Genomics/Transcriptomics
ebKB environmental bioinformatics Knowledge Base
Computational Toxicology | Risk Assessment | Diagnostic Tools
Genomics/Transcriptomics
Databases
Sequences/Maps
Genetic Markers
Proteomics
Databases
Shape/Structure
Protein Markers
NMR Spectra
Classification
Macromolecular Movements
DNA-Protein Interactions
Tools
Data Management
Search/Alignment
Classification
Structure Prediction
Post Processing and Visualization
Metadata
Standards and Markup Languages
Portals and Knowledge Libraries
Selected Literature
Metabonomics
Databases
Pathways
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Simulators
Pathway Profilers
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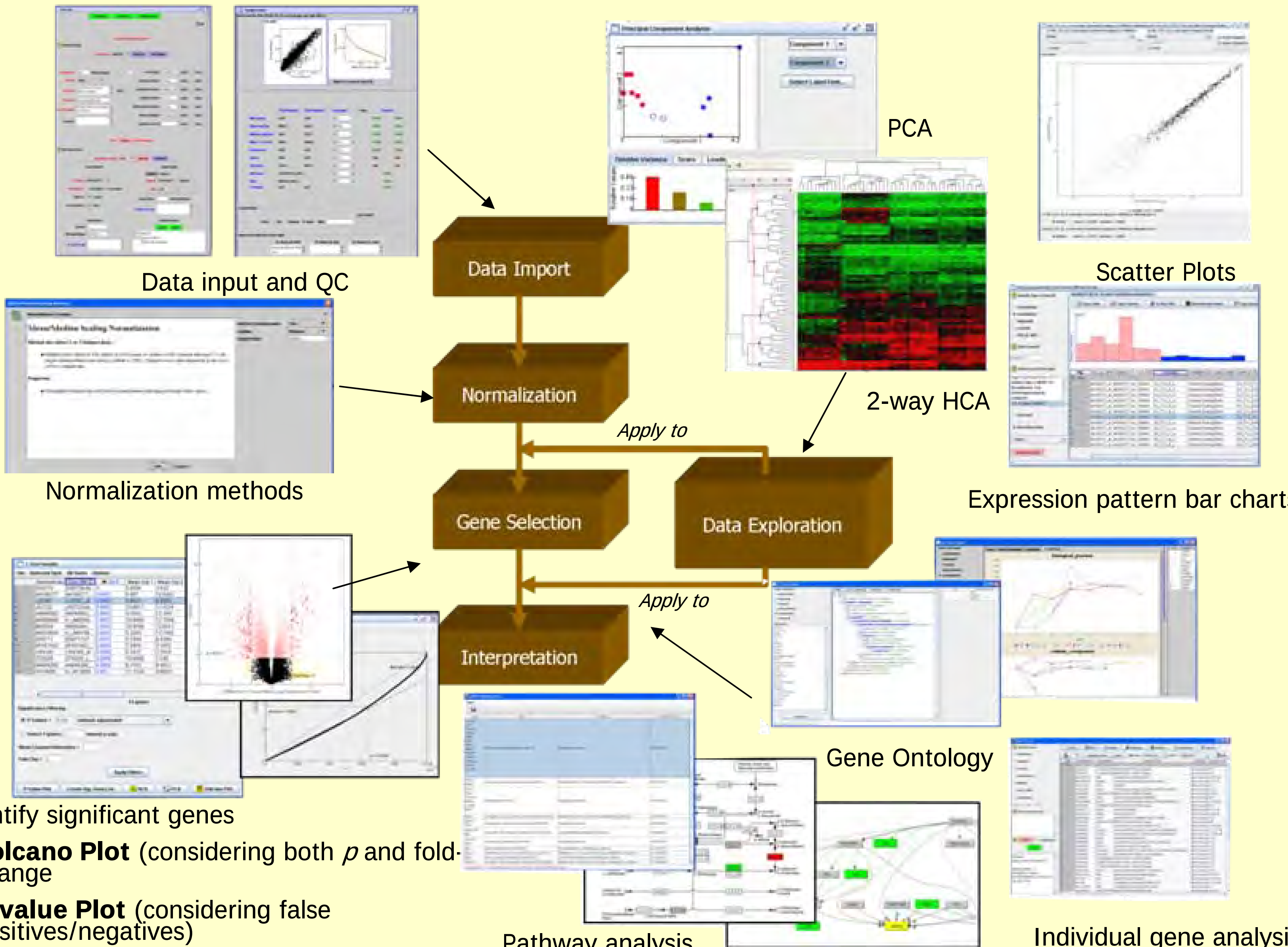
Cytomics
Databases
Apoptosis
Senescence
Signal Transduction
Oncology
Tools
Data Management
Cell Simulators
Post Processing and Visualization
Metadata
Standards and Markup Languages
Portals and Knowledge Libraries
Selected Literature
Physiomics
Databases
Model Organisms
Tools
Data Management
PBTK Models
Post Processing and Visualization
Metadata
Standards and Markup Languages
Portals and Knowledge Libraries
Selected Literature
The environmental bioinformatics Knowledge Base (ebKB) serves as a comprehensive compendium of tools, databases, and literature
Search Environmental Bioinformatics Resources
Study Type
Tissue/Organism
Advanced
Simple
Compound
Toxicol. EndPoint
CHEMINFORMATICS
Databases
QSAR
Shape Signature
Tools
Data Management
Virtual Synthesis
Similarity Search
Post Processing and Visualization
Metadata
Standards and Markup Languages
Portals and Knowledge Libraries
Selected Literature
ENVIROINFORMATICS
Databases
Concentrations and Exposures
Toxicity
Demographics and Activities
Biomonitoring
Tools
Data Management
Environmental Fate and Transport Modeling
Exposure Modeling
Dose Modeling
Integrated Modeling
Post Processing and Visualization
Metadata
Standards and Markup Languages
Portals and Knowledge Libraries
Selected Literature
BIOINFORMATICS
Integrative Databases
Integrative Tools
Integrative Metadata
BIOINFORMATICS (Genomics, Proteomics, Metabonomics, Cytomics, Physiomics)
CHEMINFORMATICS
ENVIROINFORMATICS
Computational Toxicology
Selected Literature
General Literature
Agency Reports
Journal Manuscripts
Conference Presentations
Risk Assessment
Dose-Response
Chemical Mixtures
Cross-Species Extrapolation
Diagnostic Tools
Sensitivity and Uncertainty Analysis
Pattern Recognition and Data Mining
Model/Data Assimilation and Optimization/Calibration
Missing Data Handling
Done
Adblock

ArrayTrack Suite of Bioinformatics Tools

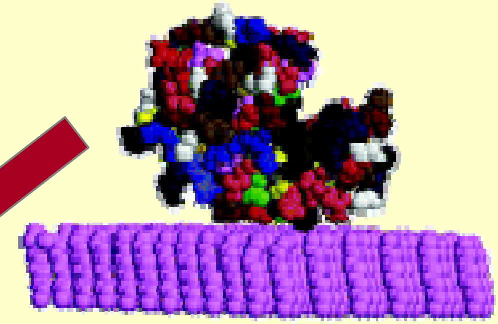


Identify significant genes

- **Volcano Plot** (considering both *p* and fold-change
- **P-value Plot** (considering false positives/negatives)

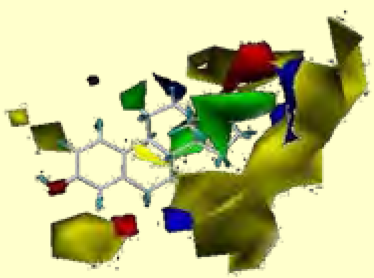
ChemTox, an Integrated Suite of Cheminformatics Tools

Protein Modeling

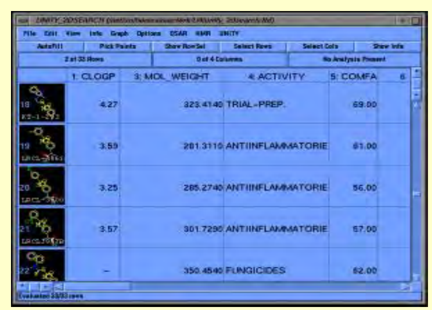


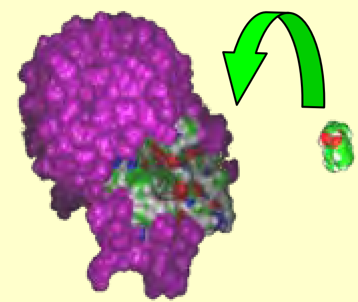
Molecule-Surface Interactions
< skin, water, polymer >

Predictive Molecular Toxicology



Chemical Modeling

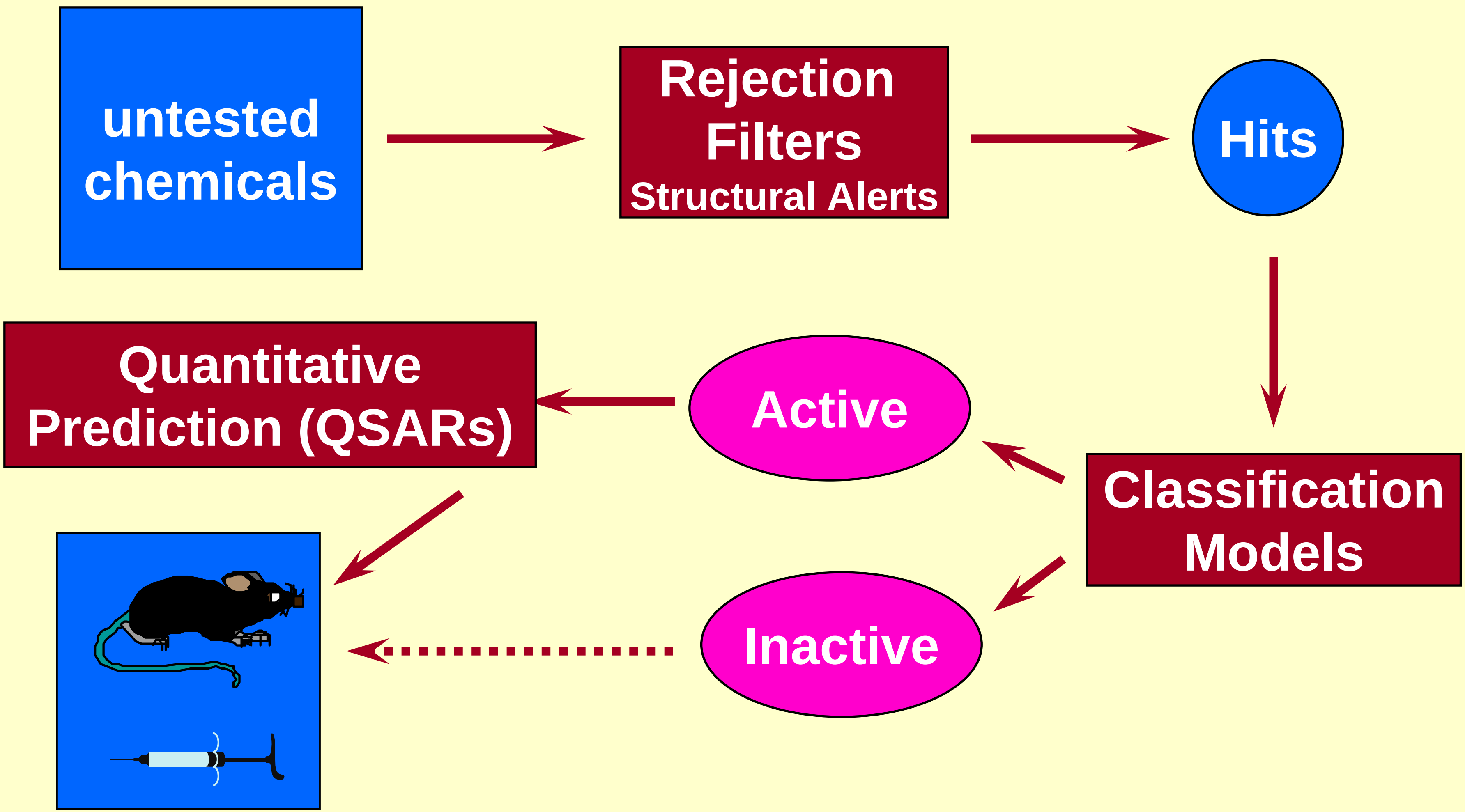




Database Mining / Pattern Recognition

Computational Screening Paradigm

- Priority Setting -



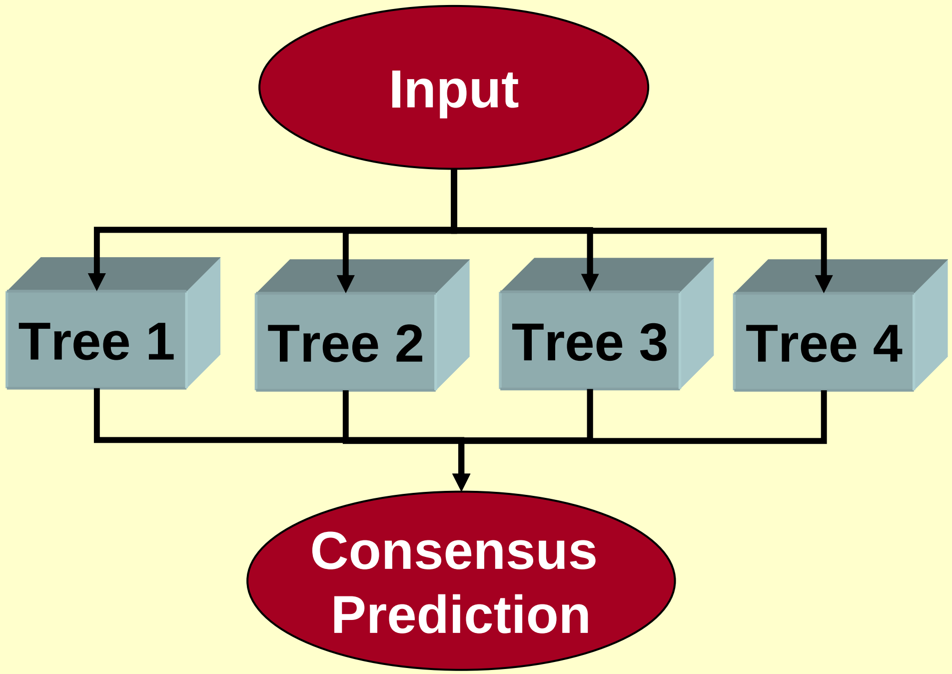
Hierarchical Screening Framework

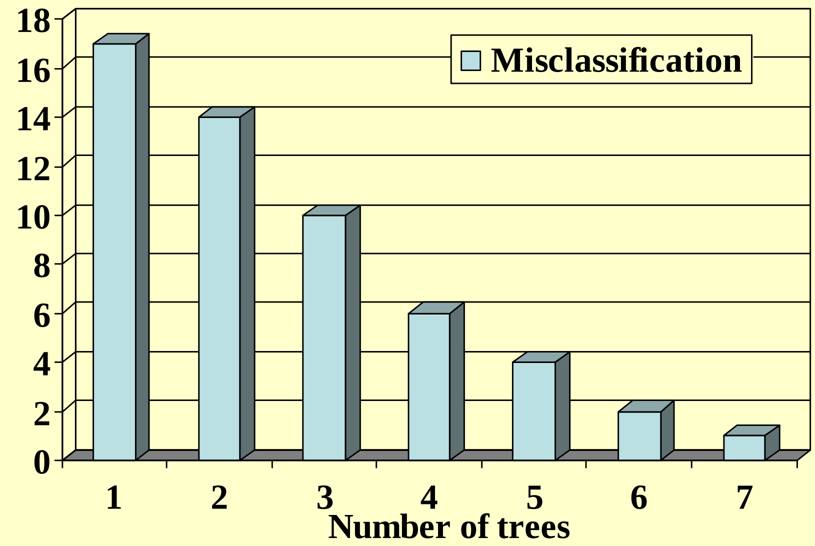
- addresses the need to minimize *false negatives* and *uncertainties*
- recognizes that no single computational model is adequate

Tier I	Rejection Filters	- MW - Structural alerts
Tier II	Classification Models (active / inactive assignment)	- Pharmacophores **- Decision Forest** **- Shape Signatures**
Tier III	Quantitative Predictions	- PLS & ANN QSAR models **- PNN QSAR model** – Receptor Docking
Tier IV	Knowledge-Base Approach	- Other priority setting factors - Human expert knowledge

Decision Forest

- Improved classification by combining independent Decision Tree models -





Key Features

- **Combining several independent yet predictive trees reduces misclassification**
- **DF structure permits assessment of prediction confidence**
- **Each tree consists of simple 'If-Then' branches, hence the DF is extremely fast**

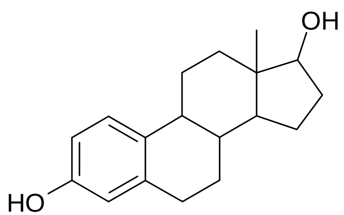
Schematic of Hierarchical Framework

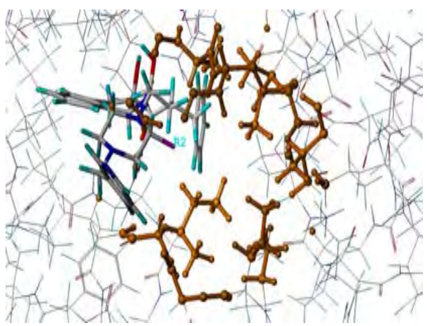
- addresses the need to minimize *false negatives* and *uncertainties* -

Tier	Approach	Components
Tier I	**Rejection Filters**	- MW - Structural alerts
Tier II	**Classification Models (active / inactive assignment)**	- Pharmacophores **- Decision Forest** **- Shape Signatures**
Tier III	**Quantitative Predictions**	- PLS & ANN QSAR models **- PNN QSAR model** – Receptor Docking
Tier IV	**Knowledge-Base Approach**	- Other priority setting factors - Modifying Tiers I, II, III - Human expert knowledge

Shape Signatures Tool

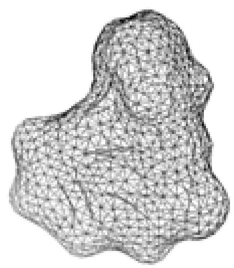
START

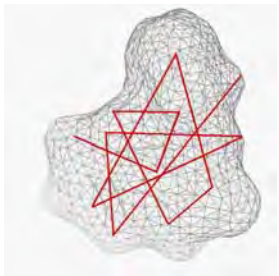


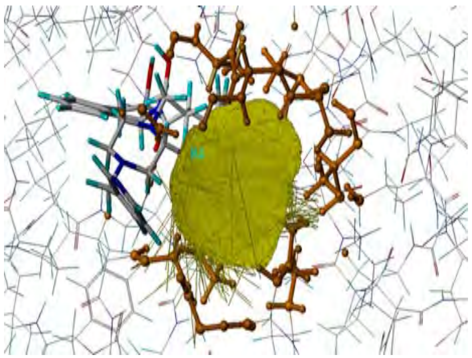


Small molecule or Protein binding pocket

PROCESSING



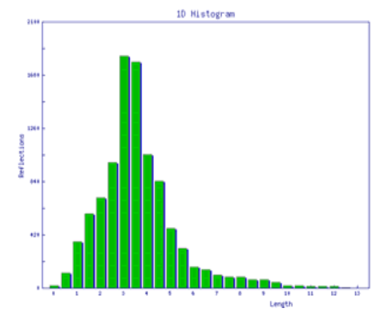




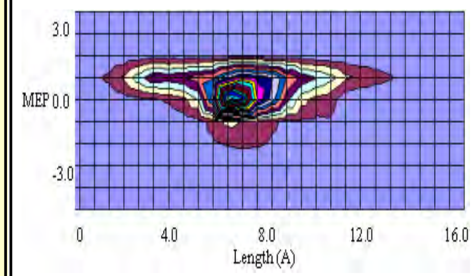
Ray tracing to generate the raw data

OUTPUT

Shape (1D)



Shape + Charge (2D)

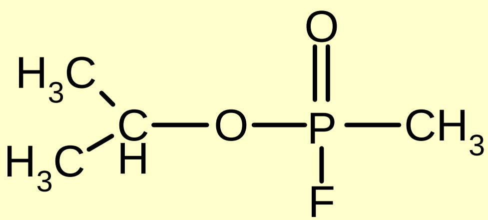


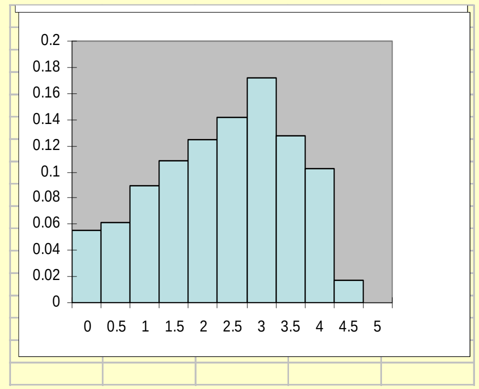
1D and 2D Shape Signatures

Shape Signatures Tool

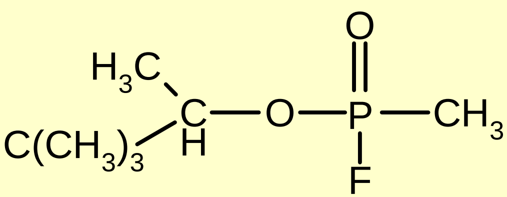
molecules are compared by subtracting their histograms

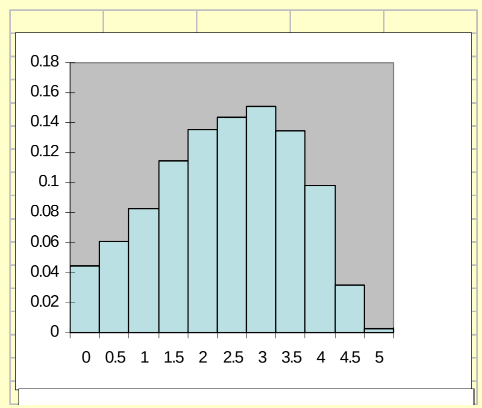
Sarin





Soman

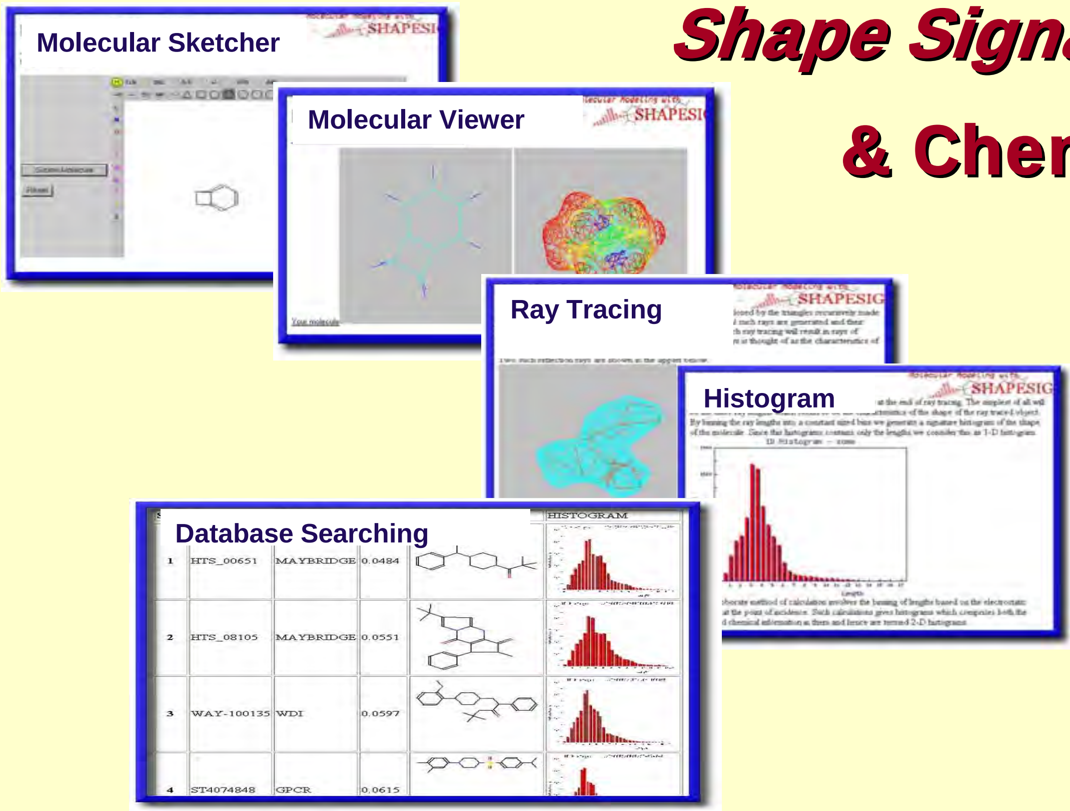




***Diff* = 0.022**

Small *Diff* value means that two molecules have similar shape and polarity

Shape Signatures Software Tool & Chemical Databases

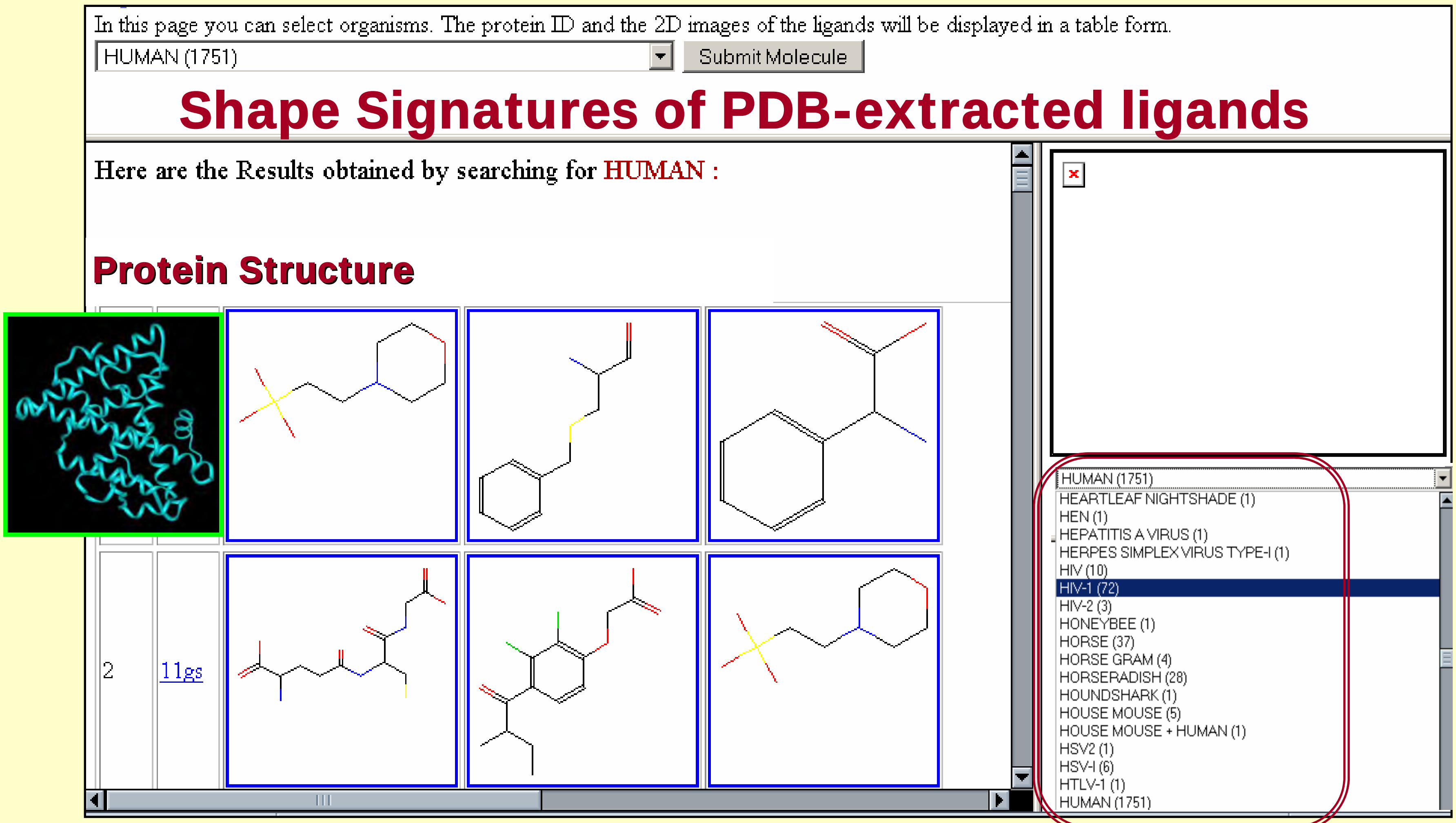


Searchable *Shape Signatures* Databases

- 3+ million commercially available organic compounds
- 40,000 Natural Products
- Hazardous Chemicals (pesticides, nerve agents, mustards, psychotropic agents, other real or potential CWAs, TICs)
- PDB-extracted ligands

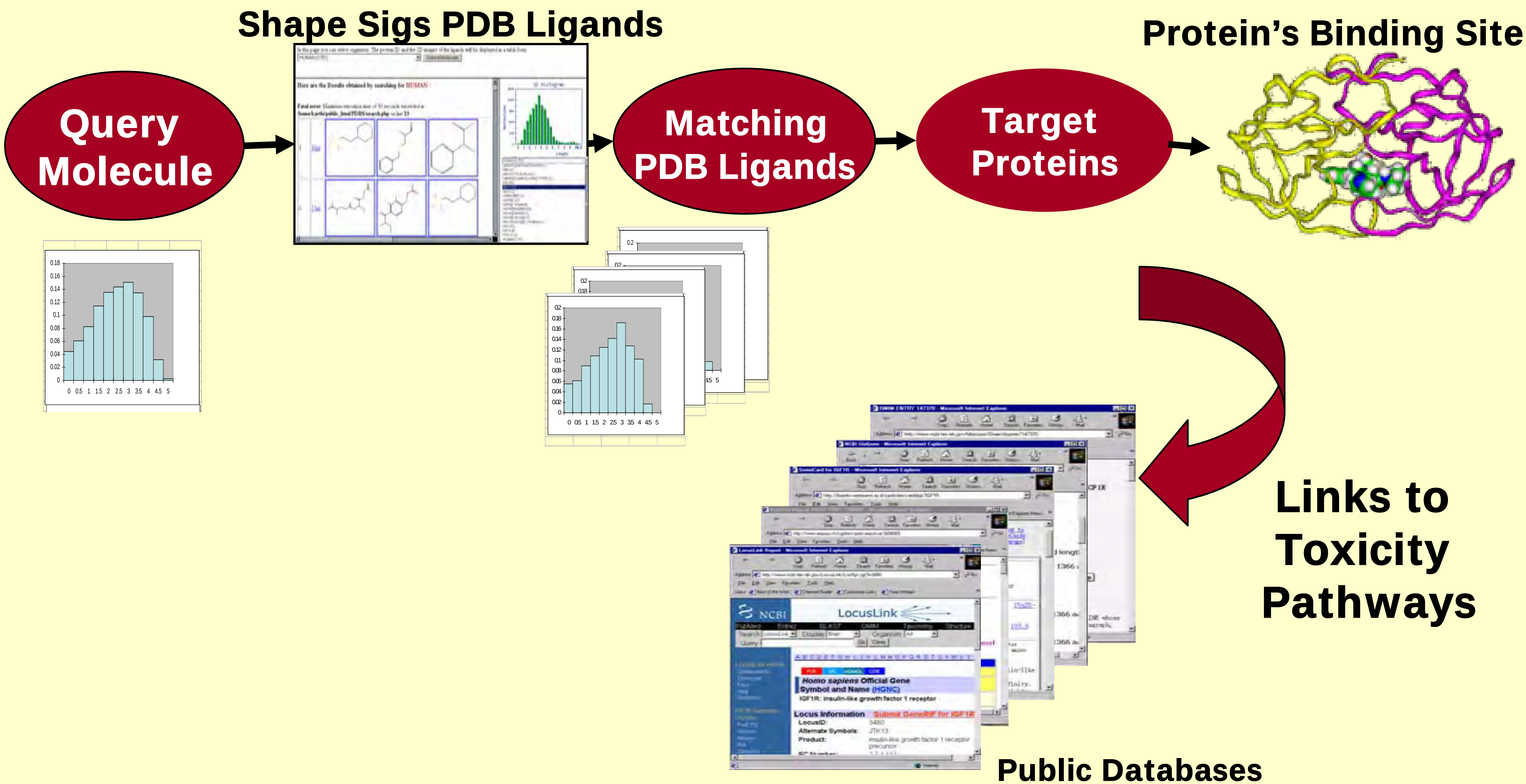
Chemical → Target Protein → Mechanisms

Protein Data Bank (PDB): World Repository of ~35,000
Protein-Ligand Crystal Structures (http://www.rcsb.org/pdb/)

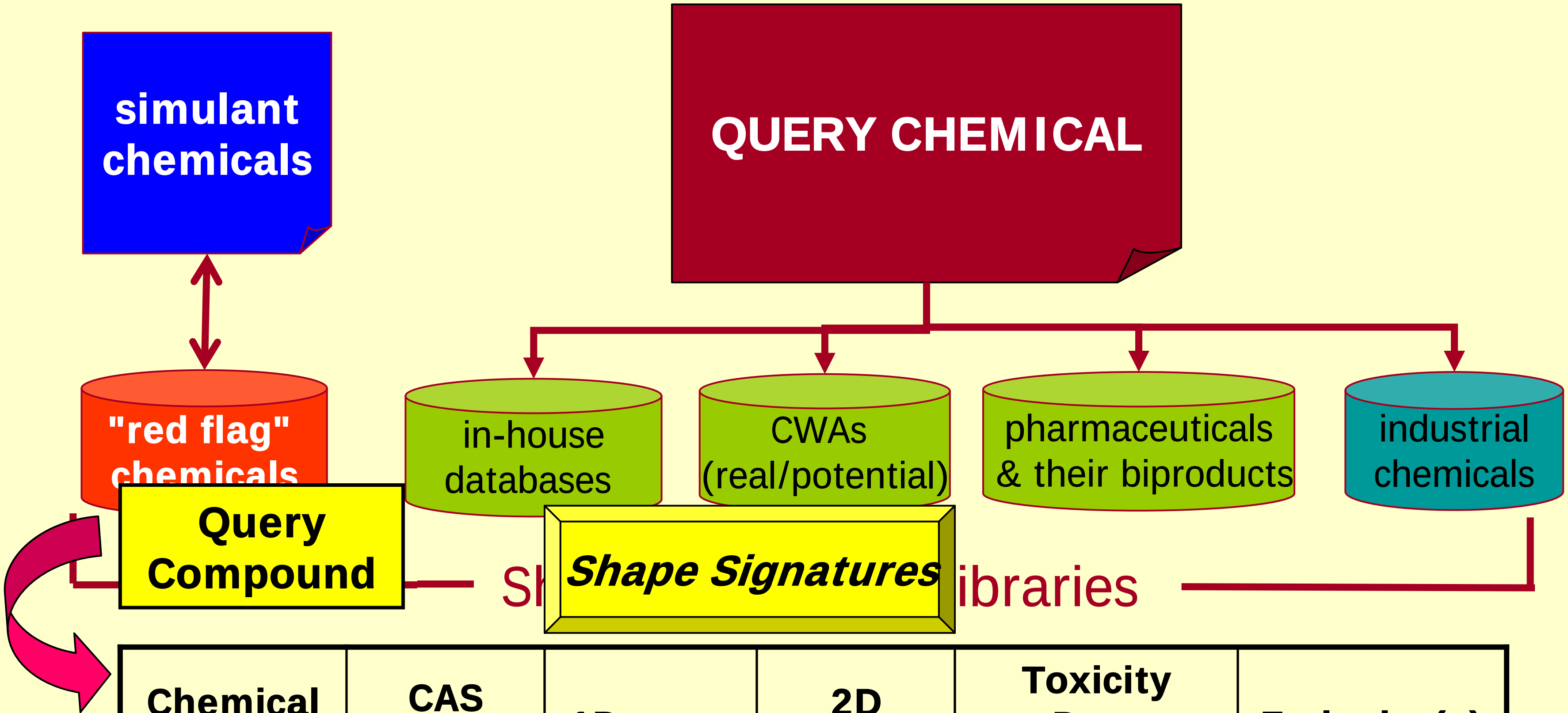


Species / Protein Family

Molecules → Target Protein → Mechanism



Identifying Problem Chemicals

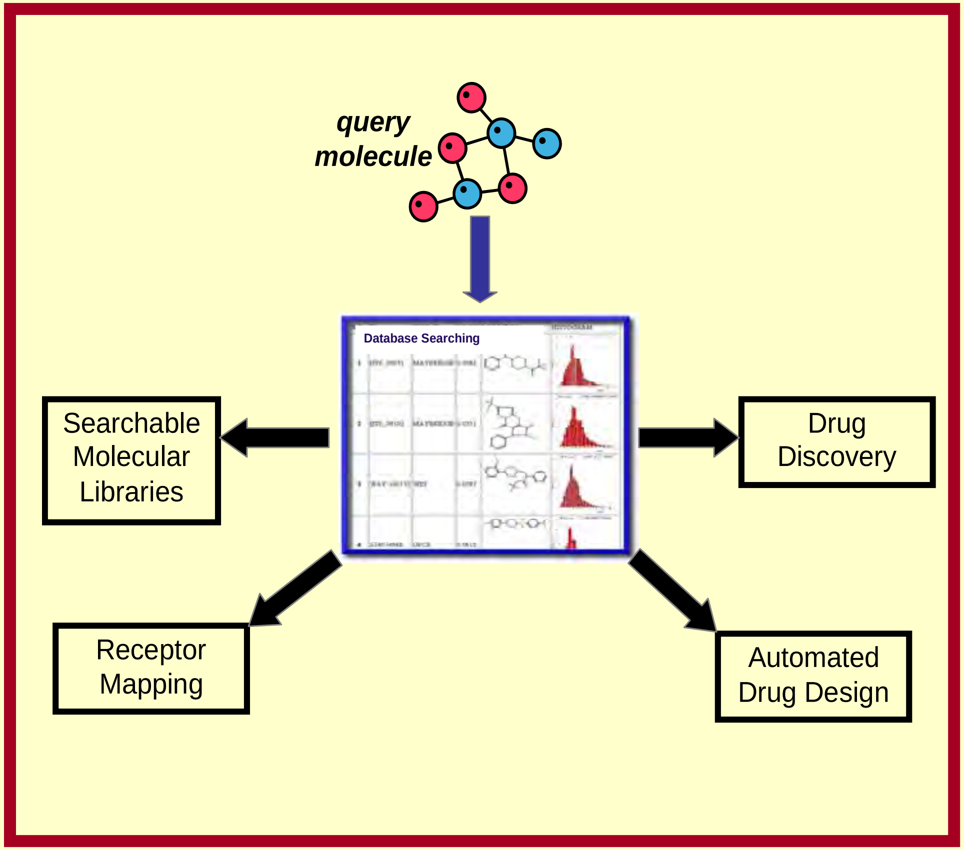


Chemical Structure	CAS Number	1D score	2D score	Toxicity Data (mg/kg-day)	Endpoint(s)

Shape Signatures

- Key Features -

- **Fast**
  screens large databases in secs
- **Extensible**
  works with any kind or number of molecular species
- **Portable**
  works on any platform
- **Versatile**
  broad utility, multiple databases



Schematic of Hierarchical Framework

- addresses the need to minimize *false negatives* and *uncertainties* -

Tier	Approach	Methods
Tier I	**Rejection Filters**	- MW - Structural alerts
Tier II	**Classification Models (active / inactive assignment)**	- Pharmacophores - **Decision Forest** - **Shape Signatures**
Tier III	**Quantitative Predictions**	- PLS & ANN QSAR models **- PNN QSAR model** – Receptor Docking
Tier IV	**Knowledge-Base Approach**	- Other priority setting factors - Modifying Tiers I, II, III - Human expert knowledge

Building QSAR Models

target property $\propto$ (molecular descriptors)

$$Y = f(X_i)$$

Types of Molecular Descriptors

Type	Example
Constitutional	Molecular composition (M_w, # of atoms/bonds, # of H-bond donors/acceptors)
Topological	2-D structural formula (Kier-Hall indices, extent of branching)
Geometrical	3-D structure of molecule (molecular volume, solvent accessible surface area, polar and non-polar surface area)
Electrostatic	Charge distribution (atomic partial charges, electronegativities)
Quantum Mechanical	Electronic structure (HOMO-LUMO energies, band gap, dipole moment)

Comparison of Regression Methods

Desirable Features of Methods and Models

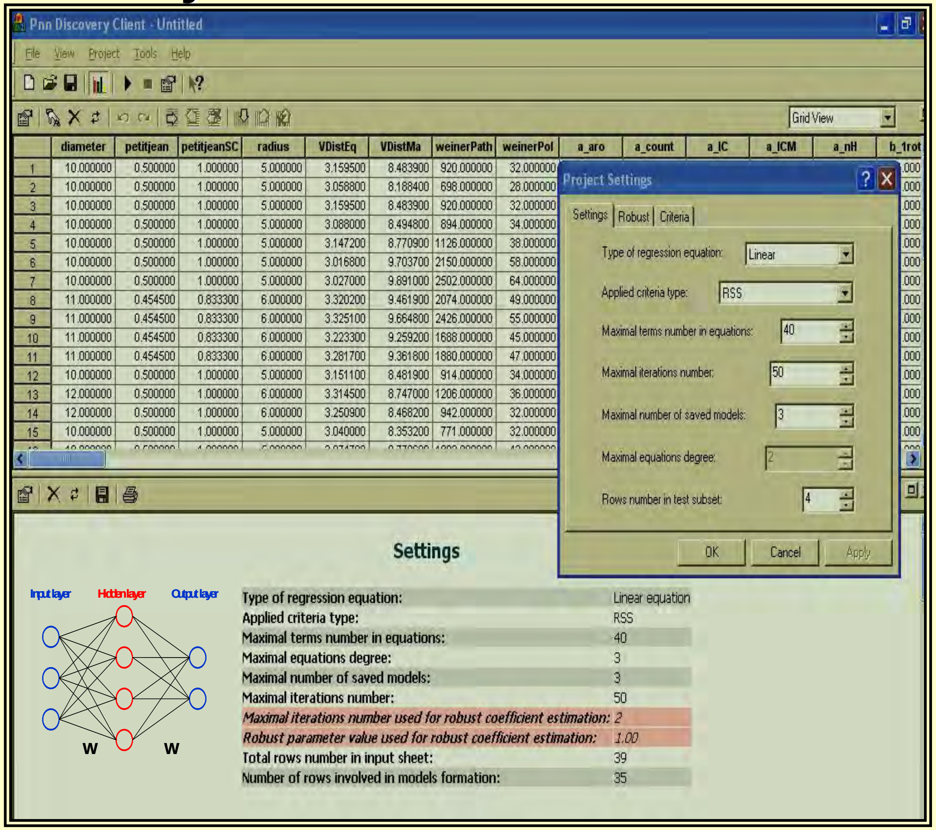
- predictions should be fast
- produces linear or non-linear models (i.e., relationship between obs toxicities and calc'd molecular features may be non-linear)
- models should be physically meaningful, interpretable, and assume parametric form

Method	Speed	Linear Models?	Nonlinear Models?	Regression Equation?	Easy to Interpret?
PLS / MVR	**	Yes	No	Yes	Yes
ANN	*	Yes	Yes	No	Yes
PNN	******	**Yes**	**Yes**	**Yes**	**Yes**

Polynomial Neural Network (PNN)

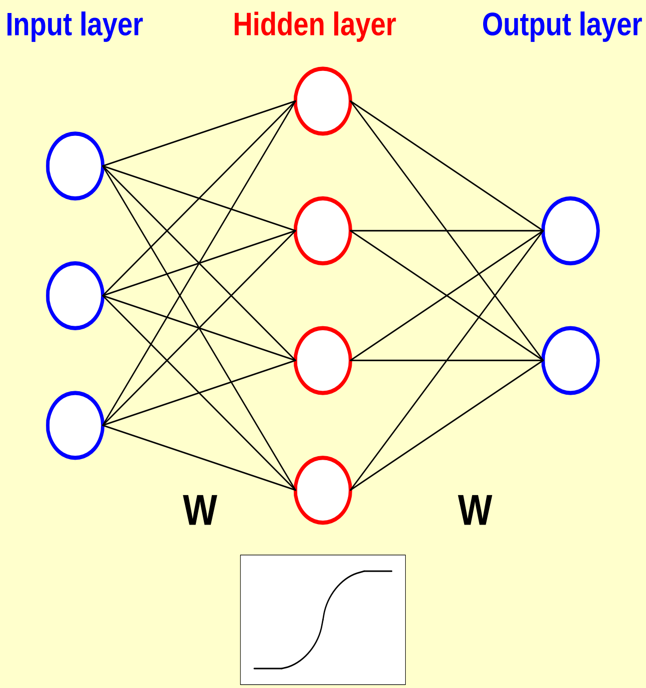
- combines best features of linear multivariate models (parametric form) and ANN models (nonlinearity) -

Polynomial Neural Network



- Produces linear or non-linear QSAR models in parametric form
- User control of model complexity
- Insensitive to irrelevant variables and outliers
- Yields predictive models, even for sparse or noisy data sets
- Trains rapidly, thus amenable to large data sets
- Automatically selects best models
- Customizable to fit user's needs

Polynomial Neural Network (PNN)



1) PNN generates parametric solutions of any desired order 'n":

$$\text{Act.} = w_1(SA) + w_2(V) + w_3(\mu) + \ldots$$

$$\boxed{\text{Act.} = w_1(SA) + w_2(V)^2 + w_3(\mu)^3 + \ldots}$$

$$\text{Act.} = w_1(SA)^2 + w_2(V) + w_3(\mu)^2 + \ldots$$

$$\text{Act.} = w_1(SA)^0 + w_2(V) + w_3(\mu)^2 + \ldots$$

$$\boxed{\text{Act.} = w_1(SA) + w_2(V)^2 + w_3(\mu)^2 + \ldots}$$

2) PNN selects best solutions:

$$\boxed{\text{Act.} = w_1(SA) + w_2(V)^2 + w_3(\mu)^3 + \ldots}$$

$$\boxed{\text{Act.} = w_1(SA) + w_2(V)^2 + w_3(\mu)^2 + \ldots}$$

Thank You!

welshwj@umdnj.edu

Shape Signatures:

Next-Generation Drug Discovery Tool

Bill Welsh

UMDNJ-Robert Wood Johnson Medical School

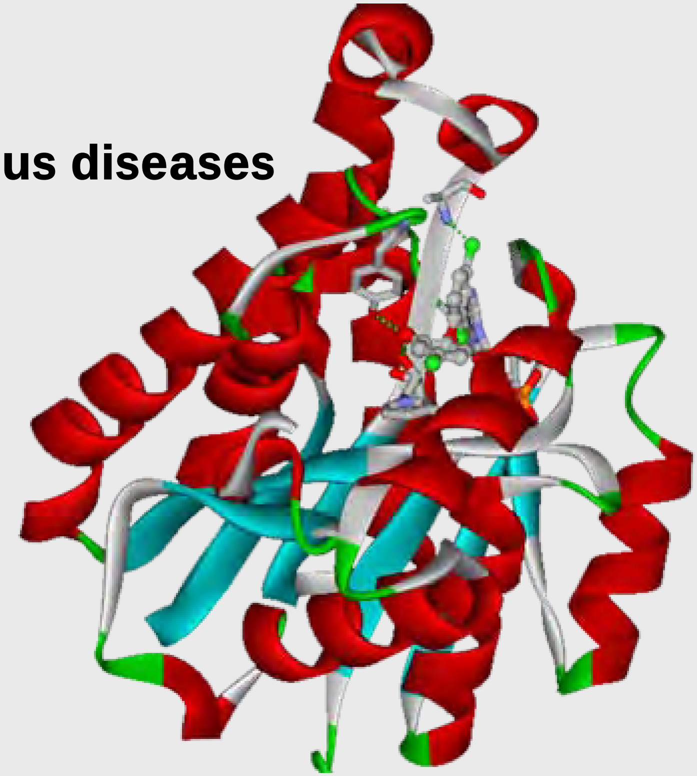
Piscataway, NJ

Voice: (732) 235-3234

Email: welshwj@umdnj.edu

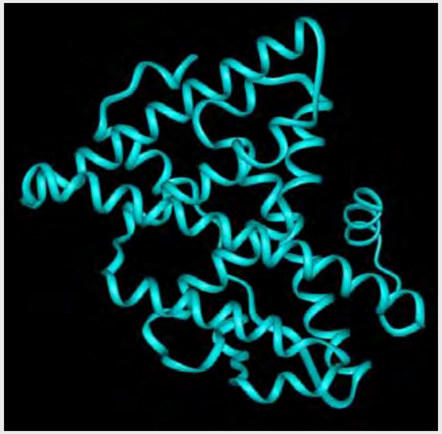
Overview of Technologies

- **Computational Tools**
  - **Rational (Computer-Aided) Drug Design**
  - **Predictive Toxicology**
- **Small Molecules**
  - **Therapeutic Areas: pain, cancer, infectious diseases**
- **Materials and Polymers**
  - **Biomaterials**
  - **Drug Delivery**



Synergistic Informatics Approaches

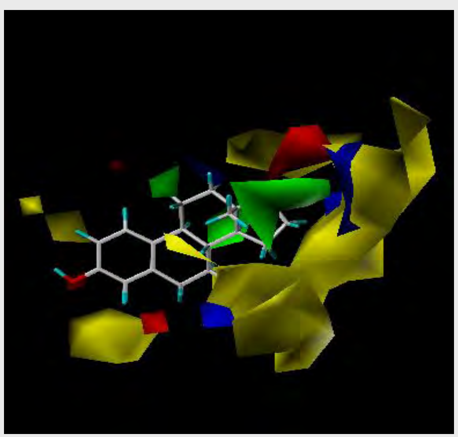
Receptor-based Approaches

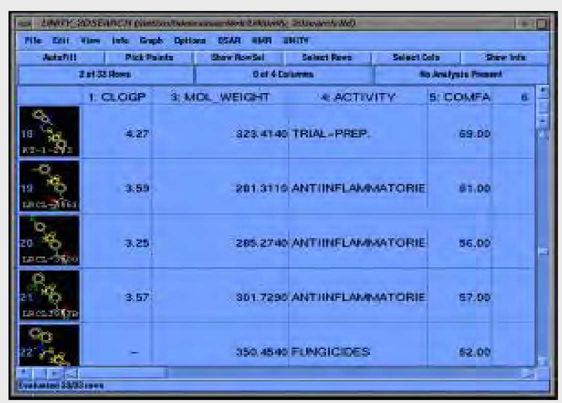


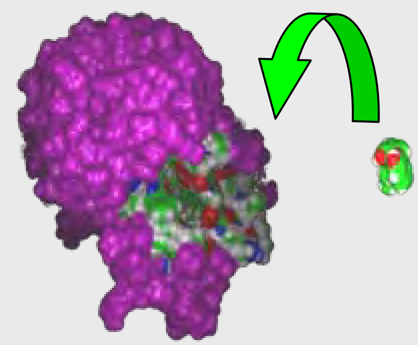
Drug Discovery

Predictive Toxicology

Ligand-based Approaches



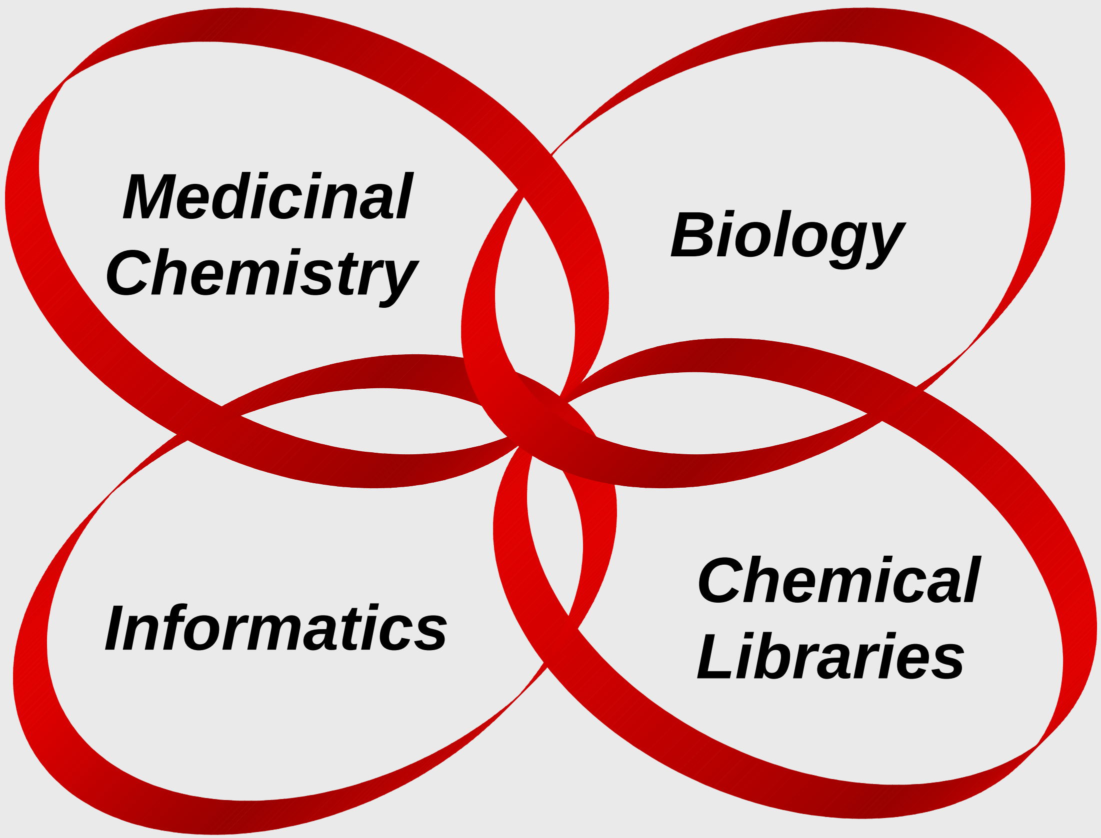




Database Mining, Pattern Recognition

Drug Discovery Paradigm

Seamless Integration of Critical Technologies



Our Integrated Discovery Platform

In Silico Design: Fast, Economical → *Time/Cost Intensive*

Protein receptor structure

Known bioactive molecule

***Shape Signatures* Chemical Library**

Initial Hits

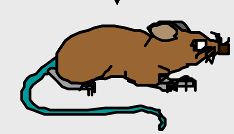
***In Silico* Screening**
- Receptor Docking
- Predicted Binding Affinity
- Drug-like Filters (Lipinski)
- ADME/Tox screens
- Database Mining
- Virtual mutations

Refined Hits

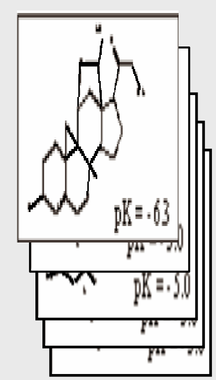
Laboratory Tests

Biological Assays

Chemical Synthesis



Tests on animal models

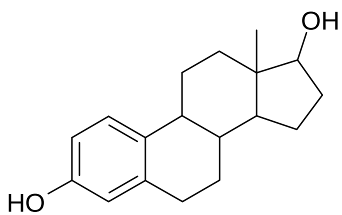


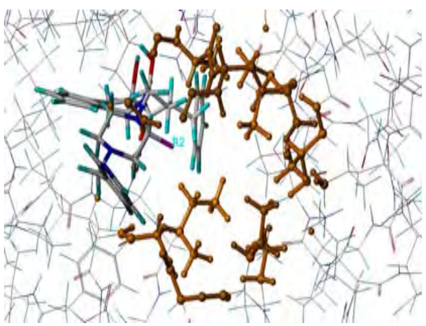
Most Promising Molecules

IND

Shape Signatures

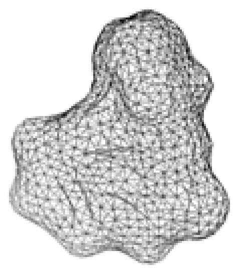
START

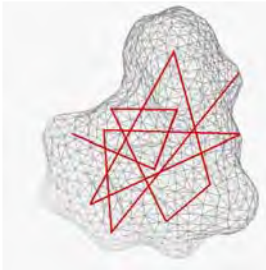


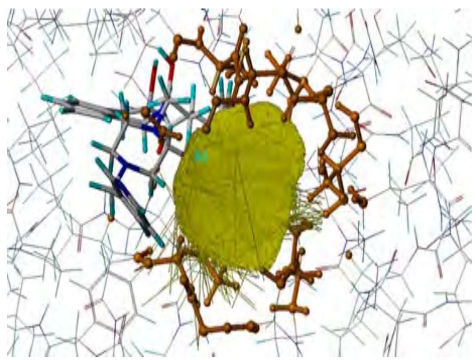


Small molecule or Protein binding pocket

PROCESSING



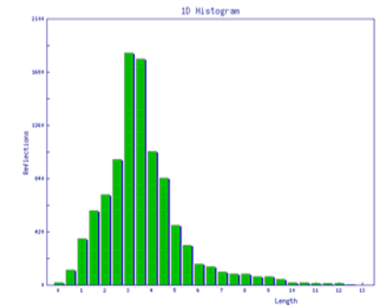




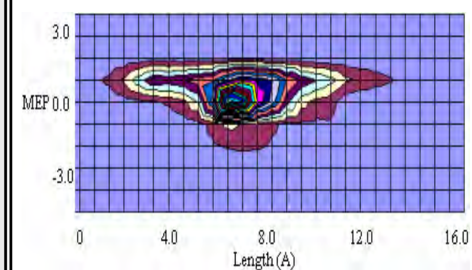
Ray tracing to generate the raw data

OUTPUT

Shape (1D)



Shape + Charge (2D)

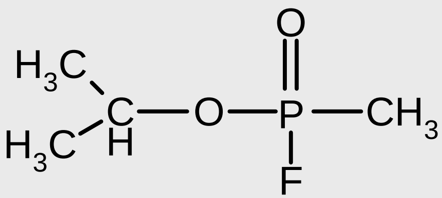


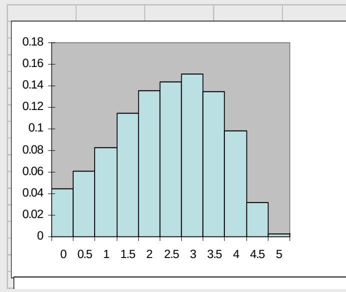
1D and 2D Shape Signatures

Shape Signatures Technology

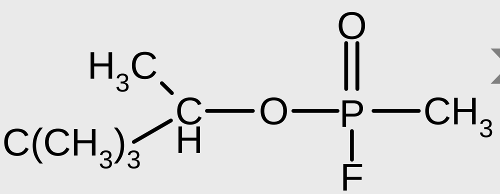
molecules are compared by subtracting their histograms

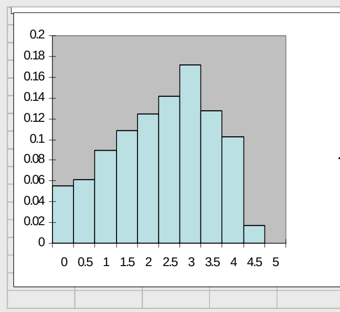
Sarin





Soman





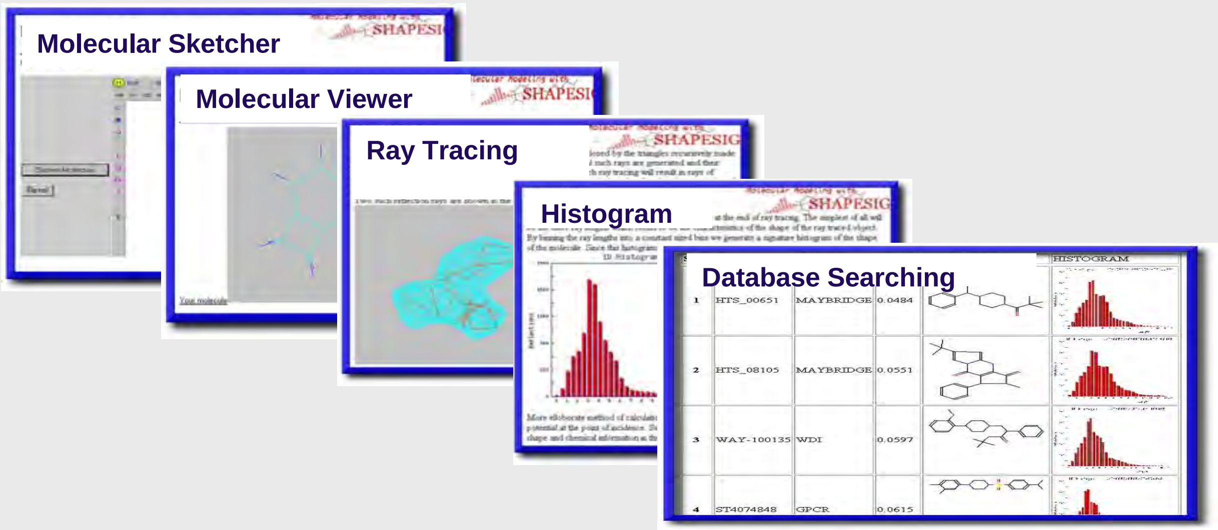
***Diff* = 0.022**

Small *Diff* value means that two molecules have similar biorelevant properties

Shape Signatures
Chemical Library

3+ million compounds

Shape Signatures Software Tool & Chemical Databases



Searchable *Shape Signatures* Databases

- 3+ million vendor available drug-like compounds
- Directed libraries for kinases, NRs, GPCRs
- Thematic libraries for indoles, pyrimidines, triazoles, etc
- 40,000 Natural Products
- 5,000 ligands extracted from Protein Data Bank (PDB)

PROTEIN DATA BANK

Extract Ligands

~35K high quality crystal structures
(resolution < 2.5 Å)

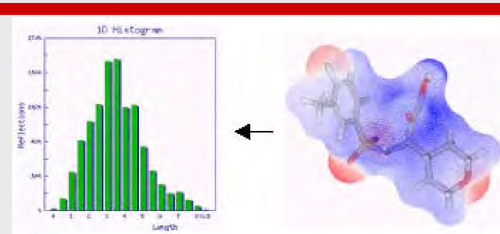
Preliminary Ligand Database

Remove metal ions, salts, redundant structures

Filter

Final Ligand Database

Convert to ShapeSig



PDB-extracted Shape Signature Database
~5,000 ligands

2D or 3D structure

Query Molecule

List of Hits With high similarity to query

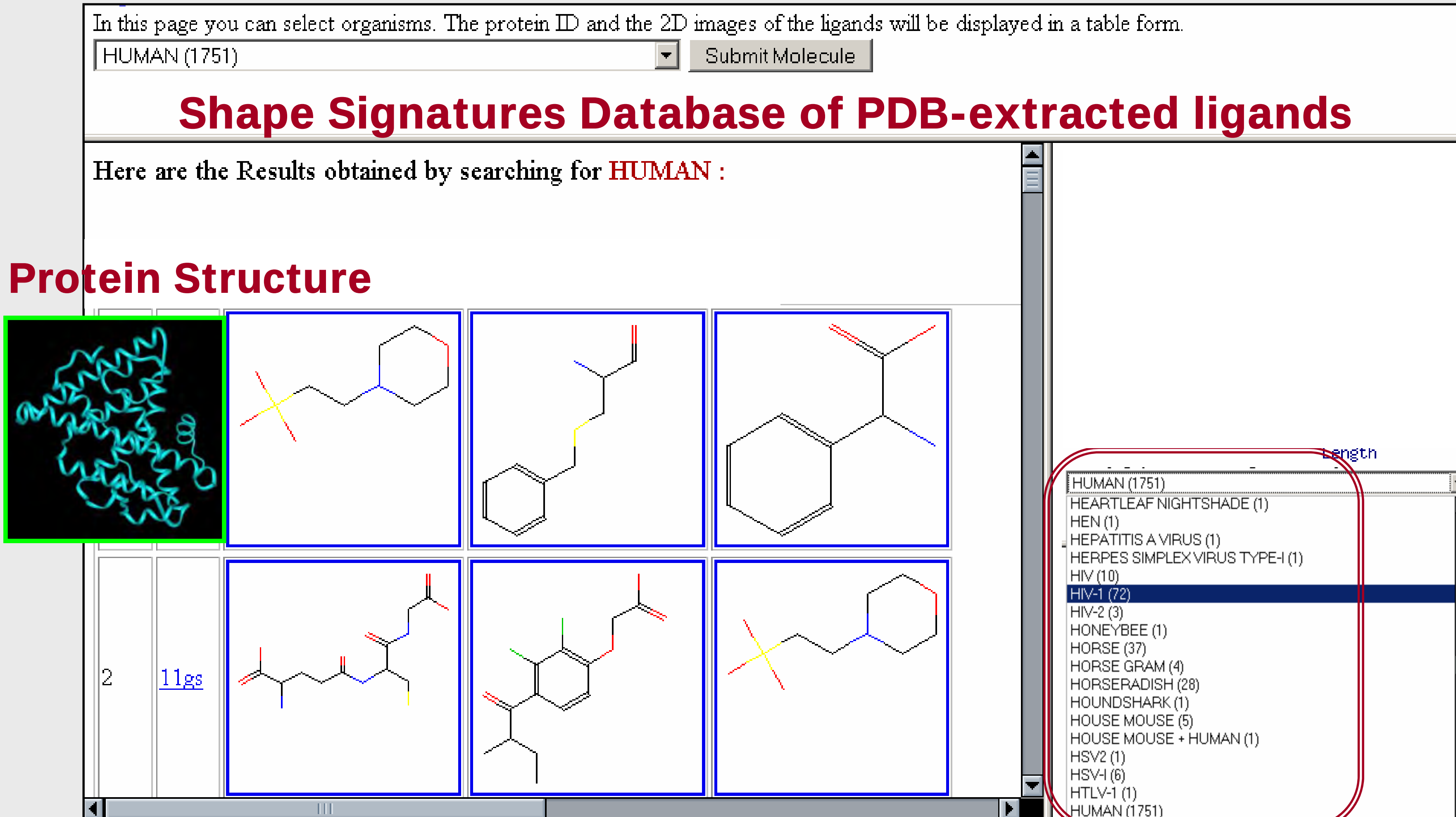
- drug-like features (Lipinski)
- parent protein ID, structure, link
- protein functionality
- pathway info

Potential Drug Leads

PDB-extracted Ligands

Novel Discovery Platform

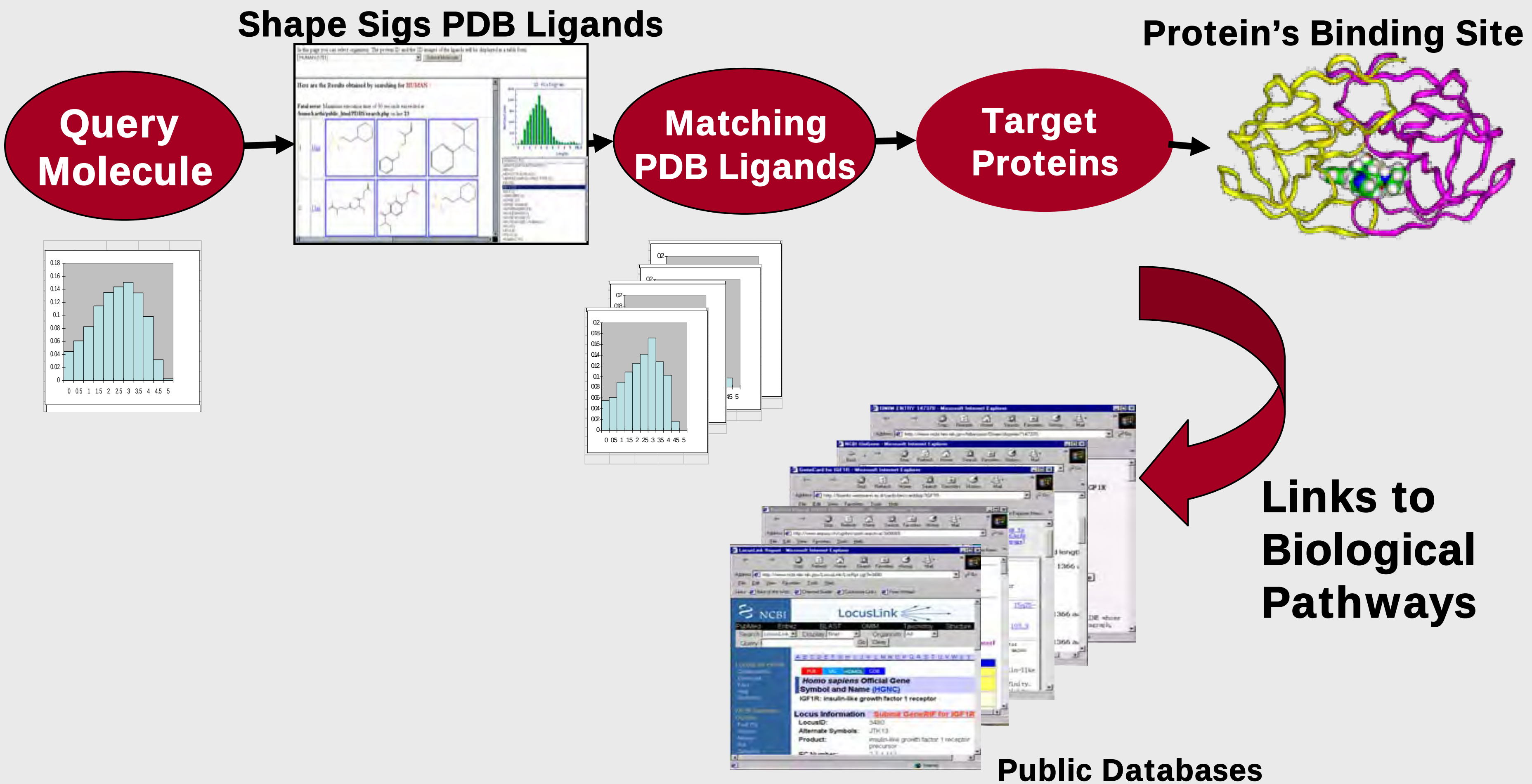
Protein Data Bank (PDB): World Repository of 35,000 Protein Crystal Structures



Protein Structure

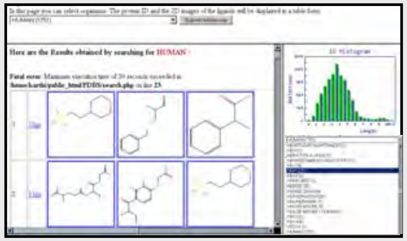
Species/Protein Family

Molecules → Target Protein → Mechanism

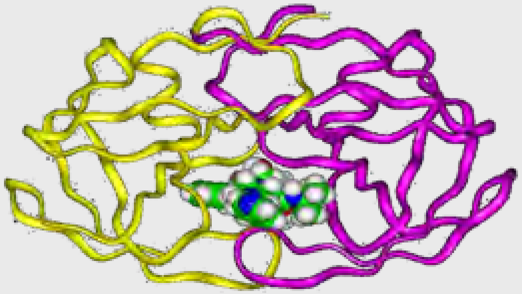


Medical Countermeasures

Novel Molecules for Detection, Diagnosis, Prevention, and Treatment of CWAs & BWAs



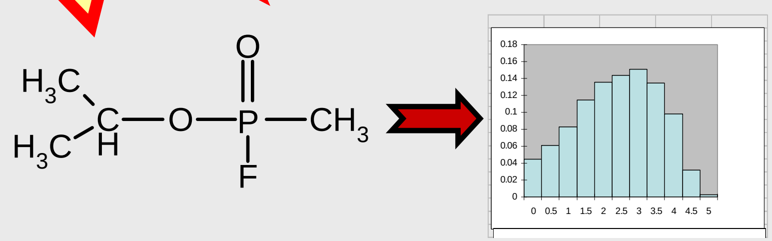
Searchable Molecular Libraries



Automated Drug Design

Shape Signatures

New Drug Candidates



CWA / BWA Target Mapping

Broad Applicability

- Therapeutics and Prophylactics
- Diagnostic Agents
- Medical Countermeasures
- Agricultural Goods
- Veterinary Medicine
- Drug Delivery Systems

Case Study

Shape Signatures for Discovery of Novel Anti-parasitic Agents

Intracellular Parasitic Diseases

- Cause acute & chronic GI distress (diarrhea) in humans and animals; life threatening; endemic
- Serious threat to warfighter stationed in endemic regions
- Examples: malaria, toxoplasmosis*, cryptosporidiosis*, cyclosporiasis*, many others

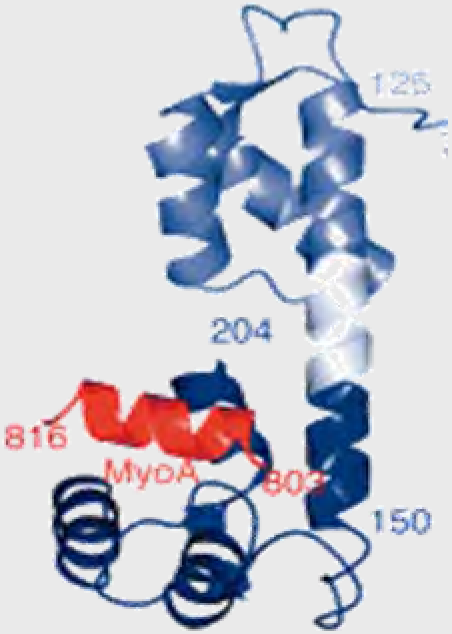
* NIAID Biodefense Category B pathogens

- Highly contagious & infectious; direct contact, insects, waterborne; resistant to disinfectants (bleach)
- No vaccines, and drugs are either non-existent, inadequate, or induce parasite resistance

Infectious Parasitic Diseases

Our Solution

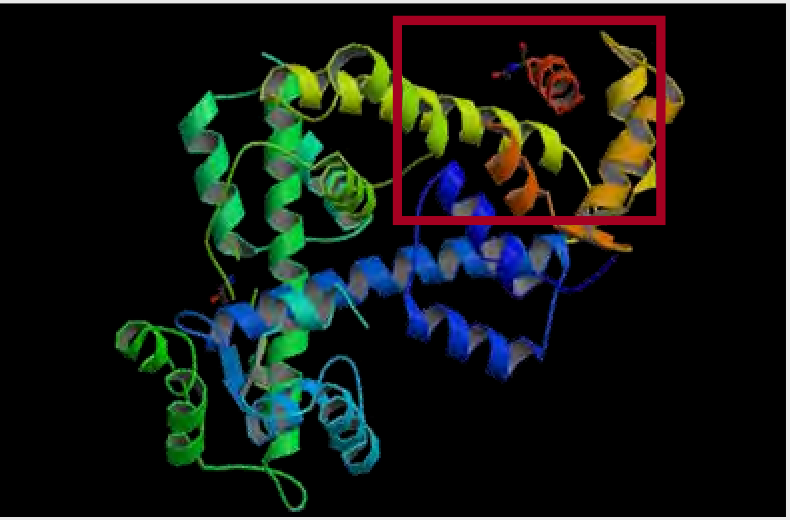
- Holy Grail: Block parasite invasion of host
- Invasion of host cells by parasite <u>requires</u> interaction of two proteins (Myosin A and MTIP)
- This interaction is unique to, and universal among, <u>all</u> of these parasites
- Myosin-MTIP Inhibitors
  - ✓ broad-spectrum activity against all species
  - ✓ high specificity for parasite over host
  - ✓ parasitic resistance virtually impossible
  - ✓ applicable for prophylaxis and therapy



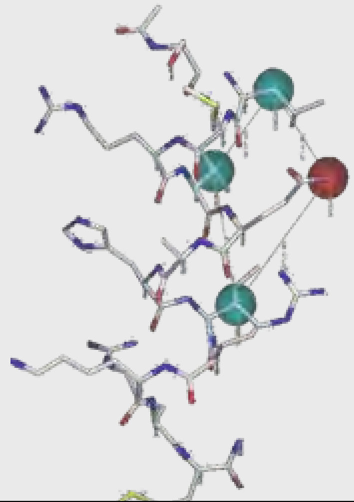
X-ray Crystal Structure of MTIP-MyoA Complex

Bosch J et al; *PNAS* (2006)

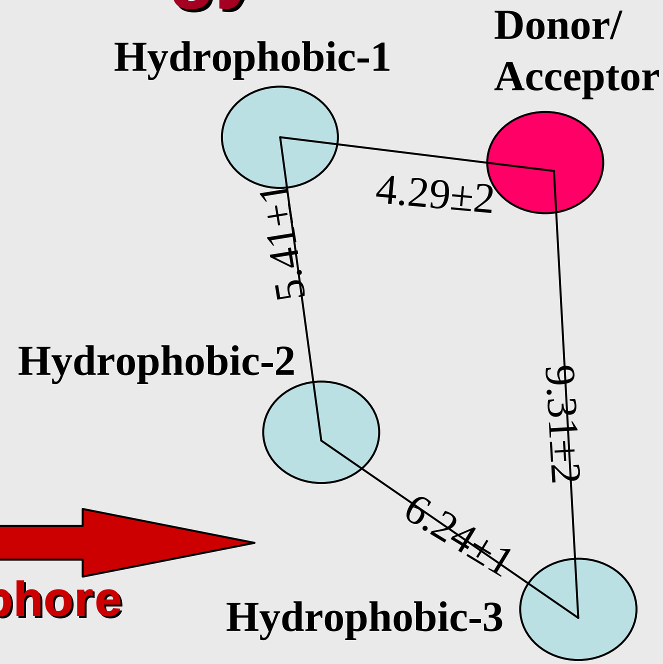
Computational Design Strategy



MTIP-Myosin A complex



Extract Pharmacophore

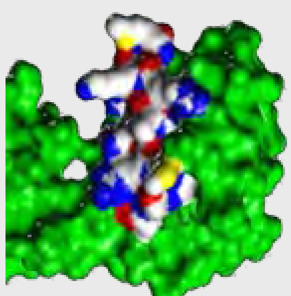


Screen Shape Sigs Library

Shape Signatures
Chemical Library

3+ million compounds

Initial Hits

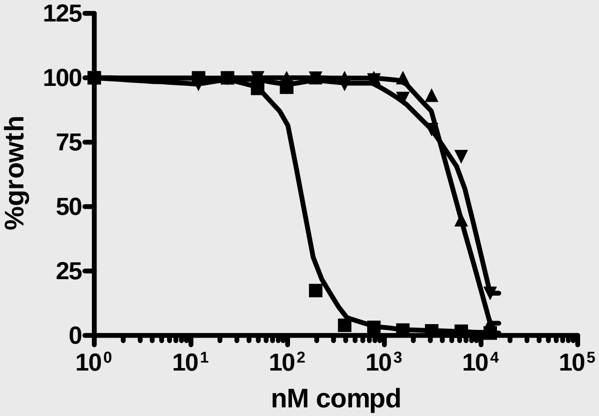


Docking of Hits

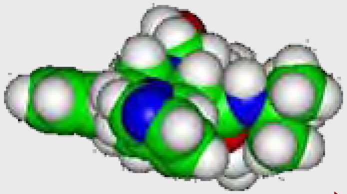
Priority List

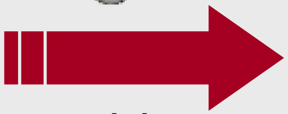
1 ...
2 ...
3 ...
4 ...
......

Family of MTIP-Myosin Inhibitors

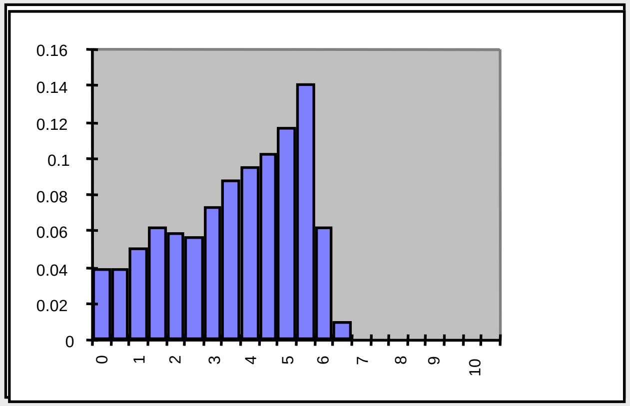


SW416: IC_{50} = 75 nM





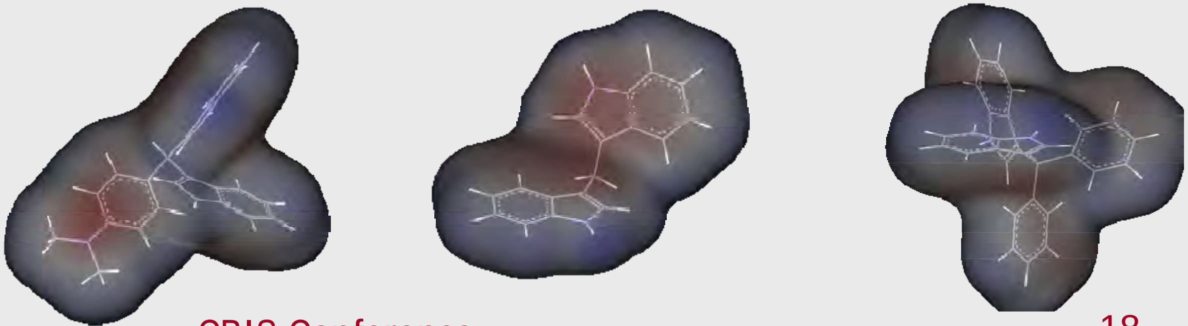
Convert to
Shape Signature



Family of Inhibitors

Drug-like Filters

Shape Signatures
Chemical Library
3+ million compounds

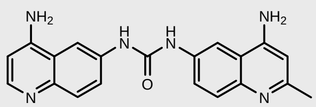
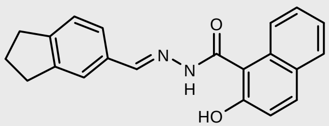
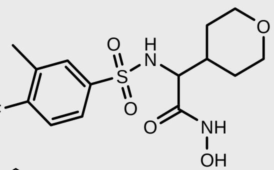
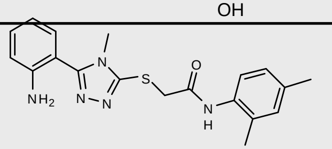
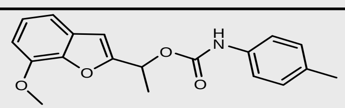
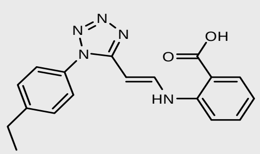


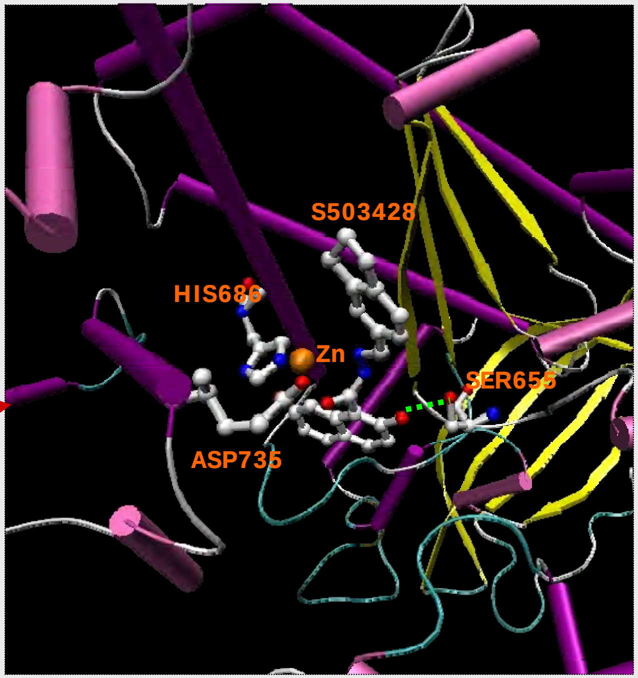
Summary

- Aided by *Shape Signatures*, we have discovered a family of potent MTIP-myosin inhibitors
- Exhibit low nM inhibitory activity against *P falciparum*, including multi-drug resistant strains
  - ✓ Block invasion of erythrocytes
  - ✓ Lethal to parasite
- Attractive drug-like properties: low MW, soluble, achiral, easy synthesis
- Non-toxic in mice (MTD > 100 mg/kg)
- Efficacy studies in mice indicate prophylactic <u>and</u> therapeutic activity
- *In vivo* studies vs other familial parasites are scheduled
  - ✓ *Toxoplasma*, *Cryptosporidium*, *Cyclospora*, *Babesia, Eimeria*
- May represent a breakthrough as broad-spectrum orally active prophylactic and therapeutic agents, with minimal chance of parasite resistance

For more details, visit: www.snowdonpharma.com

Shape Signatures: Discovery of Anthrax LF Inhibitors

ID	Structure	Source	Docking Score	% Inhibition (10 μM)
QUERY NSC 12155 (known inhibitor)		**NIH-NCI**	**33**	**95**
QUERY LFI (known inhibitor)		**Merck**	**39**	**-**
--		**S503428**	**42**	**99**
--		**G626310**	**38**	**95**
--		**B788321**	**36**	**96**
--		**HT4369**	**36**	**94**



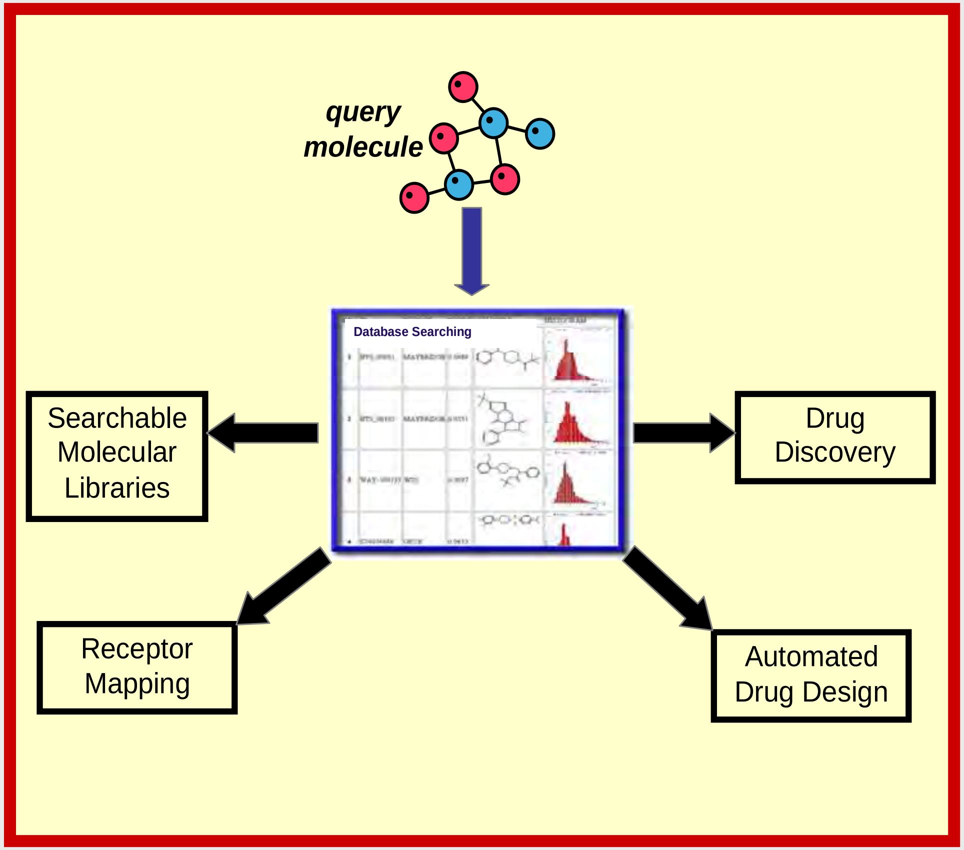
S503428 docked in the ligand binding pocket of anthrax LF

In Vitro Activity

Shape Signatures

- Innovative Drug Discovery Tool -

- **Fast**
  screens large databases in secs
- **Extensible**
  works with any kind or number of molecular species
- **Innovative**
  excels at scaffold hopping
- **Powerful**
  enables automated ligand design



Thank You!

welshwj@umdnj.edu

Visit Us: www.snowdonpharma.com

Chemical And Biological Defense Modeling and Simulation S&T Support to MDAP Thrust (CBD M&S S&T Support to MDAP)

2006

Bill Zimmerman
NSWCDD

"You must understand the real world, in order to model it"

Topics

- Purpose
- Background
- Problem Statement
- Goals and Milestones
- Challenges and Opportunities

Thrust Area Purpose

- ***To develop and transition supporting CB M&S for MDAP, and acquisition programs using M&S or M&S programs developing capabilities in support of acquisition***
  - What does this mean?
  - What is the scope of the Thrust Area?

Background

- Terminology
- Common and Cross-cutting Services, Tools, Data
- M&S is a tool
- Live, Virtual, Constructive
- Multi-resolution Environment

Terminology

- **Live**
  - "A simulation involving real people operating real systems."
- **Virtual**
  - "A simulation involving real people operating simulated systems. Virtual simulations inject Human-In-The-Loop in a central role by exercising motor control skills (e.g., flying an airplane), decision skills (e.g., committing fire control resources to action), or communication skills (e.g., as members of a C4I team)."
- **Constructive**
  - "A simulation involving simulated people operating simulated systems. Real people stimulate (e.g., make inputs) to such simulations, but are not involved in determining the outcomes."

Reference: DoD Modeling and Simulation (M&S) Glossary, Jan. 98

Terminology (continued)

- **M&S Interoperability**
  - The ability of a model or simulation to provide services to and accept services from other models and simulations, and to use the services so exchanged to enable them to operate effectively together.

***Reference*: DoD Directive 5000.59, "DoD Modeling and Simulation (M&S) Management," January 4, 1994**

***Reference*: DoD 5000.59-P, "Modeling and Simulation Master Plan," October 1995**

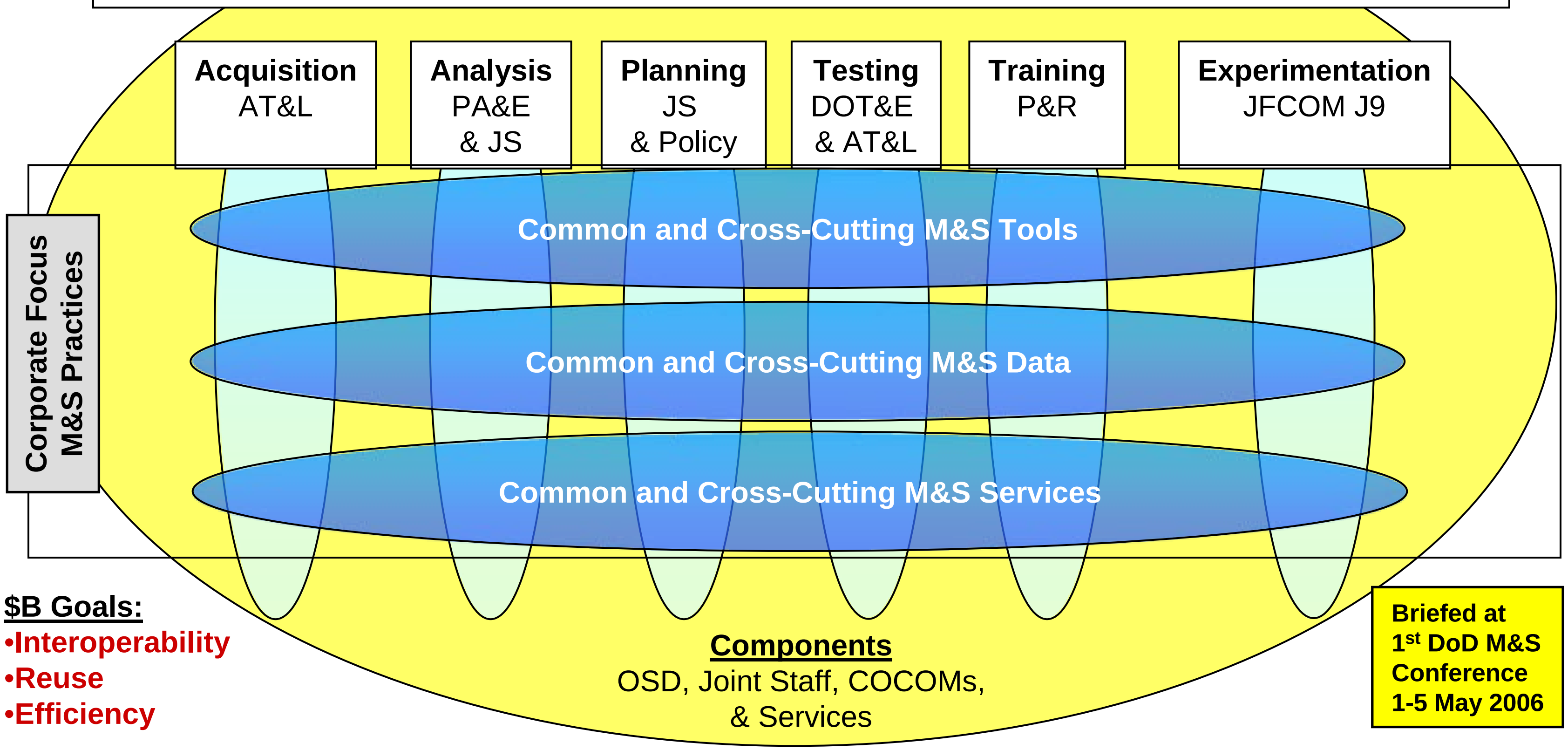
Terminology (continued)

- Distributed Simulation
  - Linking together of independent, geographically separate simulations or simulators
  - Tremendous potential for helping ensure combat readiness, especially for combined or joint combat operations
  - Can involve multiple types of military simulations (i.e., live, virtual and constructive)
  - Linking different simulations and simulators depends on a network architecture
    - Allows data and information to be sent, received and used in a consistent manner
  - **Issues during distributed simulation events**
    - **standardized databases, real-time versus faster- or slower-than-real-time simulations, and the accuracy or validity of the underlying models upon which the simulation is based**

The New M&S Framework

• Organized by Communities
• DoD M&S coordination structured to support the Communities

1/2 -Star M&S Steering Committee (M&S SC) provides governance.
DMSO transitions to M&S Coordination Office (M&S CO)-- supports the M&S IPT and SC.



$B Goals:
- **Interoperability**
- **Reuse**
- **Efficiency**

Briefed at 1st DoD M&S Conference 1-5 May 2006

NAVSEA WARFARE CENTERS DAHLGREN

Traditional Modeling and Simulation

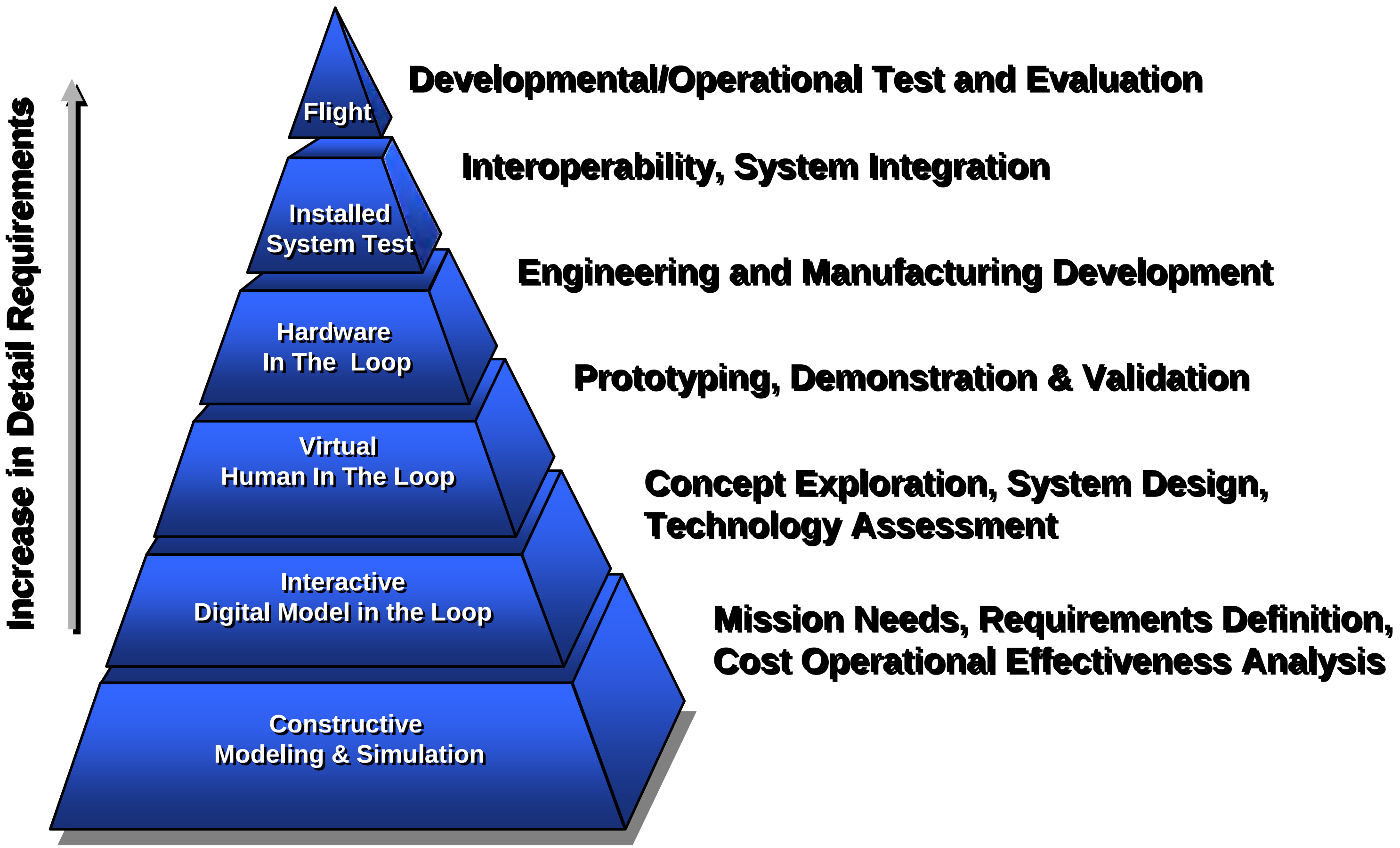
Aggregation

Level	Use
Campaign	• Force Effectiveness • Force Survivability • Campaign Outcomes
Mission	• Mission Effectiveness/Lethality • Survivability • Mission Outcomes
Engagement	• System effectiveness • Vehicle capabilities
Engineering	• Sub-system definition • Integration of sub-systems • System performance

Detail

NAVSEA WARFARE CENTERS DAHLGREN

M&S Support Capability



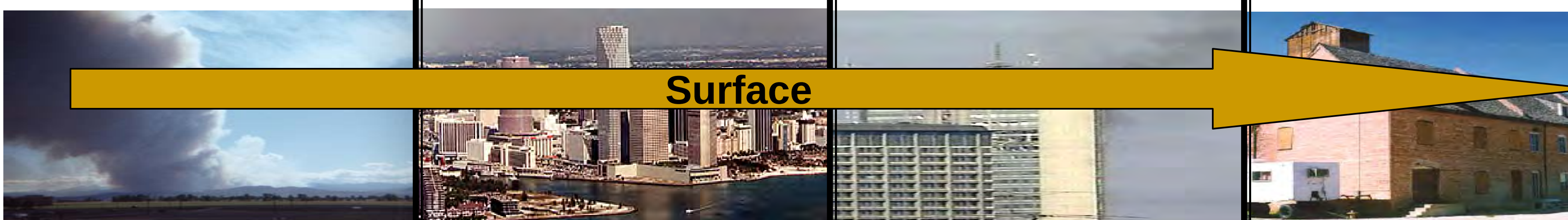
CBRN Multi-resolution Environment

Far Field	Mid Field	Near Field	Internal

Atmospheric

Global	Meso	Local	Micro

Interactions in Boundary Areas



Surface

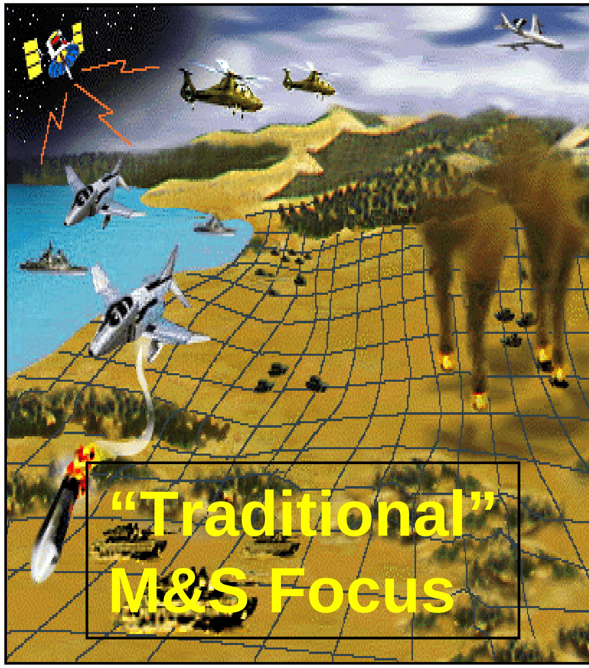
Interactions in Boundary Areas

Water

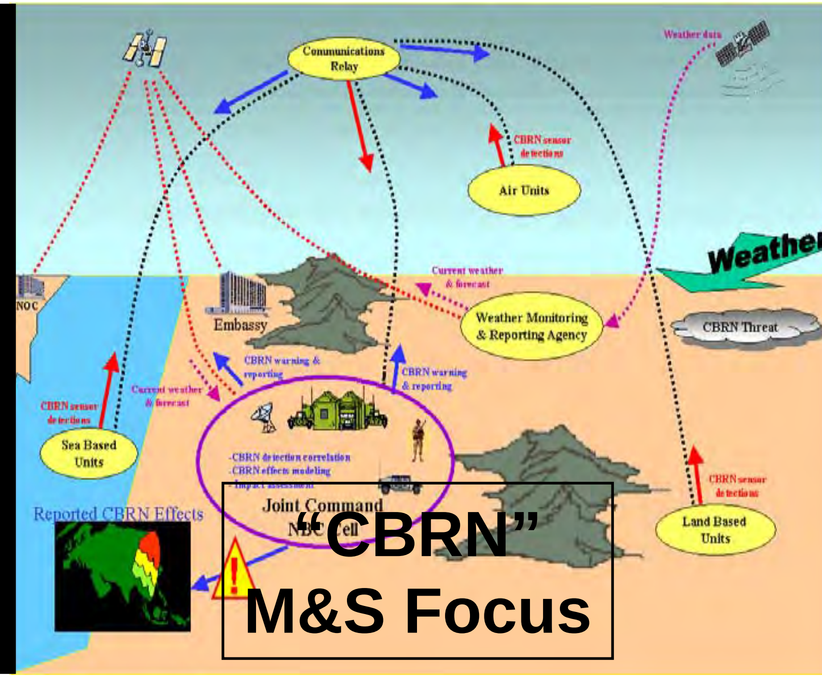
Large Open Bodies of Water	Lake and River	Near Water Intake	Internal Water Distribution

NAVSEA WARFARE CENTERS DAHLGREN

Virtual Environment



Common Elements?

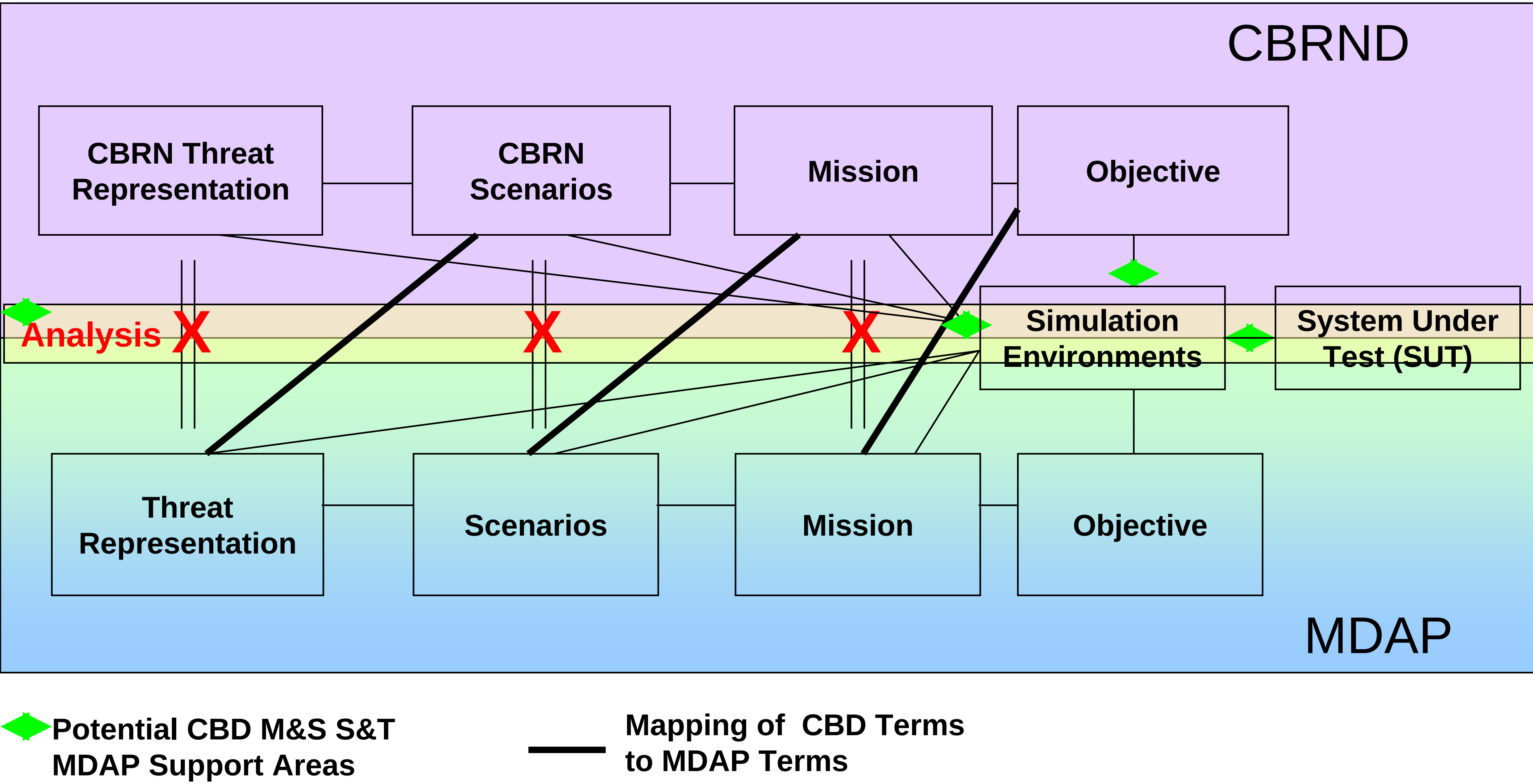


Live

Virtual

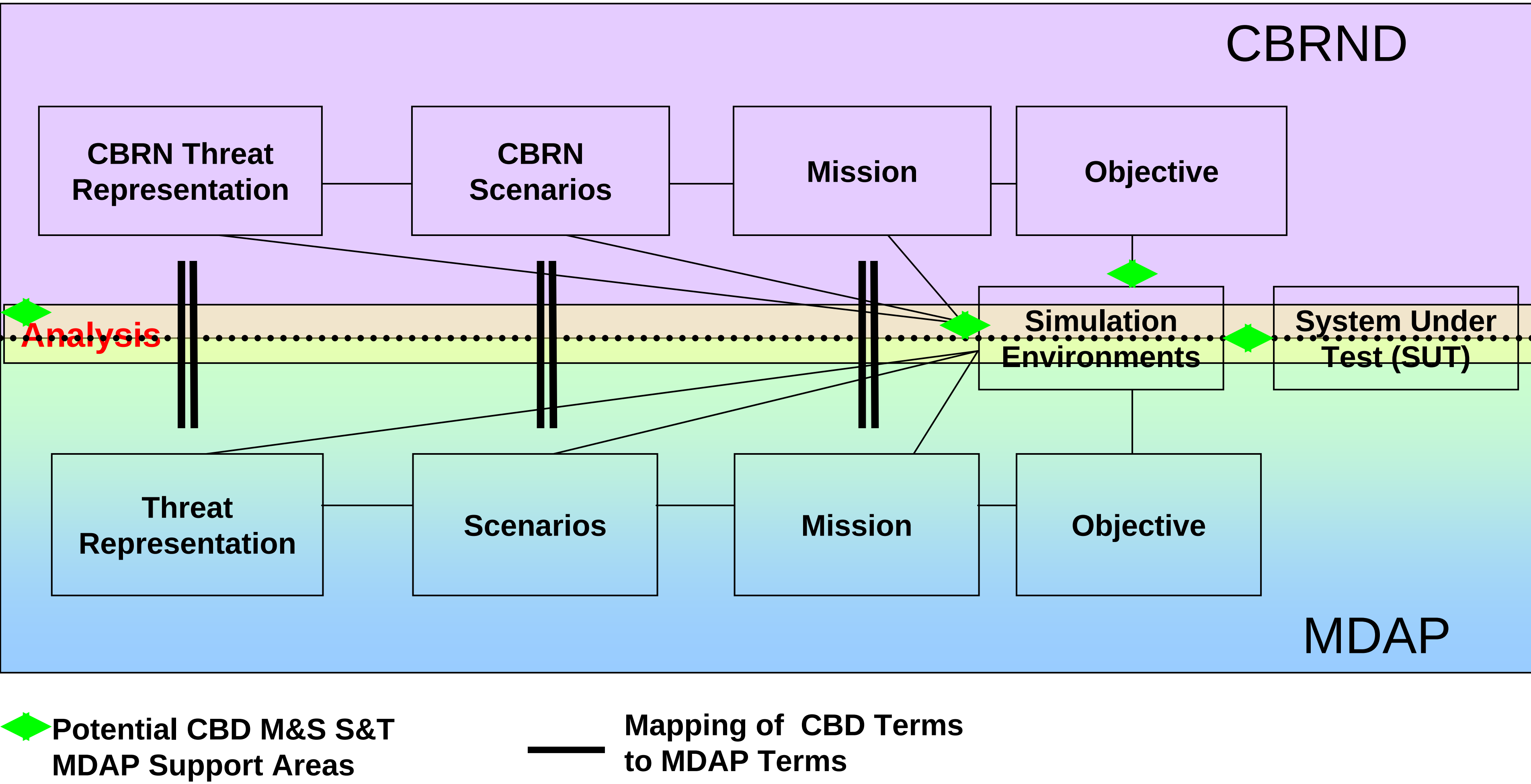
Constructive

CBD M&S S&T MDAP Support Problem Statement (Current View)



NAVSEA WARFARE CENTERS DAHLGREN

CBD M&S S&T MDAP Support Problem Statement (Future View)



NAVSEA WARFARE CENTERS DAHLGREN

Major Goals and Milestones

- Near Term (FY07 – FY08)
  - Identify Acquisition Program CBD M&S S&T needs
  - Establish pilot S&T program with FCS
  - Establish collaboration activity between broader M&S and CBD M&S
  - Participate with Simulation Interoperability Standards Organization (SISO) Study Group (SG) on LVC Architecture Interoperability
  - Transition initial pilot program
- Mid Term (FY09 – FY11)
  - Identify additional Acquisition Program CBD M&S S&T needs
  - Establish common S&T areas among MDAPs
  - Transition program
- Far Term (FY12 & Beyond)
  - TBD (based on initial efforts)

Challenges and Opportunities

- The CBD M&S S&T MDAP Support Area will
  - Develop interoperability, and supporting analysis technology supporting CBD M&S and MDAP M&S
  - Established architecture or framework for analysis & technology trade-offs
  - Rapidly transition interoperability technology to MDAP
  - Leverage capabilities across DoD, collaboration with US government, universities, companies, foreign countries
  - Support the conduct of concept evaluations by depicting proposed concepts, promising technologies, doctrine, possible TTPs in a synthetic environment, and exercising them in appropriate scenarios.
  - Provide an authoritative and consistent representation of the CBRN environment

Questions?